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R. A. F. FLYING TRAINING MANUAL.

PART II.

APPLIED FLYING.

AIR MINISTRY.

V. M. Schmidt

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AIR PUBLICATION 928.

ROYAL AIR FORCE FLYING TRAINING MANUAL

PART II—APPLIED FLYING

This Part deals with the Training of Pilots for war.

The principles of Flying Training, which have been evolved by perience as generally applicable to the training of Pilots, must be ictly observed.

By Command of the Air Council,

W. F. Nicholson

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CHAPTER I

NIGHT FLYING

General Principles

1. Owing to the growing effectiveness of anti-aircraft armament and to the development of air fighting, the operations of aircraft flying over territory occupied by hostile forces are increasingly subject to interference. At night, on the other hand, the difficulties of observation from the ground are great, and the chances of opposing air forces encountering one another are less; it follows that aircraft may be employed to carry out missions during the hours of darkness which would often prove impossible of execution by day.

2. The ability to operate during the hours of darkness not only prolongs the time during which aircraft can be employed, but increases the number of duties for which they may be utilised in war; moveover, naval and military forces will execute the major part of their strategical movements under cover of darkness, with the object of escaping air observation, and the power of aircraft to observe and attack ground forces by night must therefore be developed.

3. The duties for which aircraft may be employed at night include the following :—

(i) Attack of aerodromes and of aircraft upon the ground.
(ii) Air fighting.
(iii) Attack of ground objectives.
(iv) Attack of naval forces and shipping.
(v) Reconnaissance.
(vi) Observation of artillery fire.
(vii) Propaganda.
(viii) Transport of individuals or small bodies of troops for special duty behind the enemy's lines.

4. Every engine of war as it is produced or perfected calls for the development of counter measures; it is therefore essential, not only to extend the operations of aircraft, but to frustrate similar efforts on the part of an enemy.

5. Probably the most effective method of preventing a hostile air force from operating at night, is to attack its aerodromes and destroy its aircraft on the ground. Air fighting at night, owing to restricted visibility, will generally be limited to an area in which fighting pilots can co-operate with the ground personnel operating searchlights and anti-aircraft guns.

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6. The moral effect of destroying a hostile aeroplane at night is considerable and acts as a great deterrent to hostile bombing operations.

Requirements for Night Flying

7. Night flying presents no serious difficulties, provided that aircraft are specially equipped for the purpose; that landing grounds with the necessary lighting arrangements are provided; and that pilots are carefully trained.

8. The success of flying by night, as by day, depends on the qualities of both pilot and aircraft. In addition, an efficient organisation on the ground, carefully trained personnel, and a suitable method of communication between the pilot and the controlling authority on the aerodrome are essential.

9. The qualifications required of a night flying pilot are :—

(i) Skill and confidence in flying by day.
(ii) Knowledge of his engine and complete familiarity with the use of all his controls and instruments.
(iii) Keen eyesight.
(iv) Knowledge of air pilotage.
(v) Experience in night flying.

10. Most types of aircraft may be employed for night flying, and these must necessarily vary according to the duties for which they are intended; the following characteristics are, however, essential :—

(i) Good field of view for the pilot,
(ii) Stability.
(iii) Slow landing speed.

11. All aeroplanes used for night flying are equipped with two signalling lamps, known as *identification lights*, fitted, one to the under-side of the fuselage showing downwards, and one to the top-side of the centre-section showing upwards. The identification lights are operated by means of a Morse key, and are used for the purpose of communicating with the ground or other aircraft. The lamps are covered with a glass slide which can be changed to conform to the colour of the day.

12. In order to prevent collisions in the air, and to facilitate recognition, aeroplanes carry navigation lights which may be kept alight as long as the pilot is flying over territory occupied by friendly troops unless the tactical situation demands otherwise.

13. Navigation lights consist of :—

(i) Forward, a white light visible in a dihedral angle o 220 degrees bisected by a vertical plane through the line of flight, and of such a character as to be visible at a distance of at least five miles.
(ii) On the starboard side, a green light so constructed and fixed as to show an unbroken light between two vertical planes whose dihedral angle is 110 degrees

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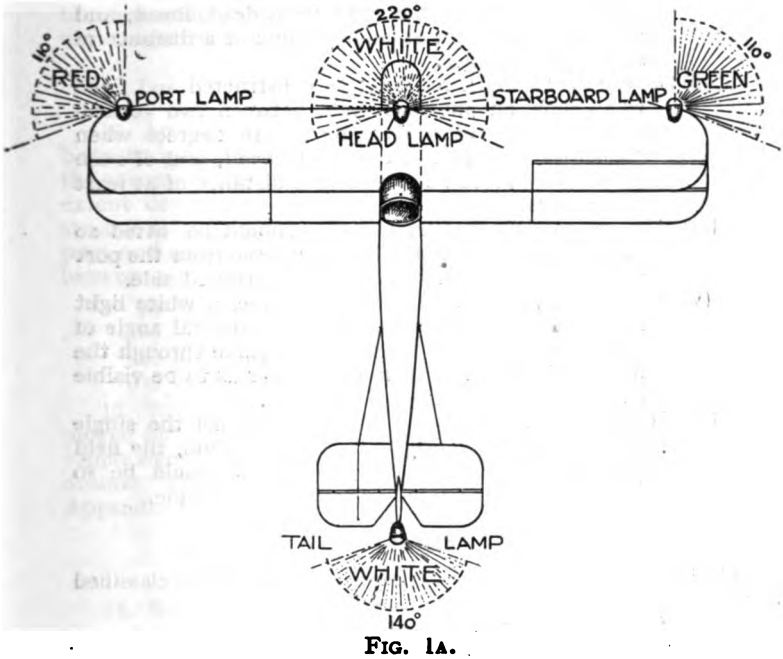
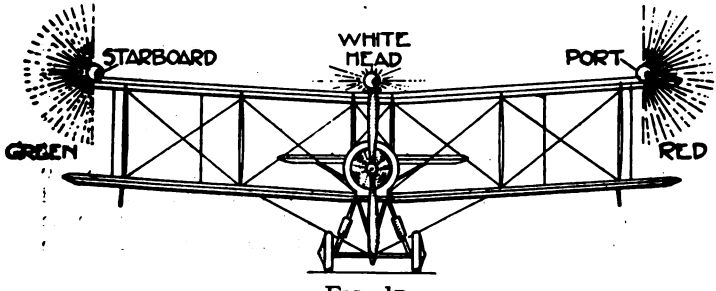


FIG. 1A.



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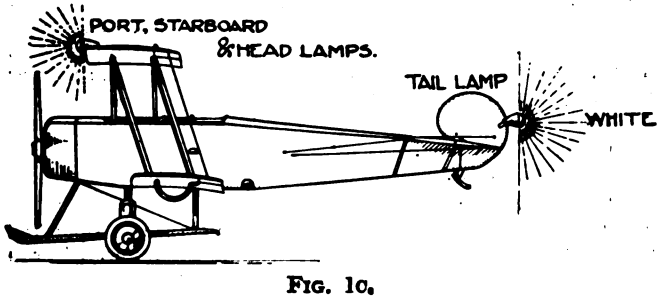

FIG. 1C.

FIGS. 1A, B & C.—ARRANGEMENT OF STANDARD NAVIGATION LIGHTS.

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when measured to the right from dead ahead, and of such a character as to be visible at a distance of at least three miles.

(iii) On the port side, a red light so constructed and fixed as to show an unbroken light between two vertical planes whose dihedral angle is 110 degrees when measured to the left from dead ahead, and of such a character as to be visible at a distance of at least three miles.

(iv) The green and red side lights should be fitted so that the green light should not be seen from the port side, nor the red light from the starboard side.

(v) At the rear, and as far aft as possible, a white light shining rearwards and visible in a dihedral angle of 140 degrees bisected by a vertical plane through the line of flight and of such a character as to be visible at a distance of at least three miles.

(vi) If in order to fulfil the above conditions the single light has to be replaced by several lights, the field of visibility of each of these lights should be so limited that only one can be seen at a time.

Flares

14. Flares may be used for various purposes and are classified as :—

(i) Landing flares.
(ii) Wing-tip flares.
(iii) Reconnaissance flares.

15. (i) *Landing flares* are used on the aerodrome to denote the landing area and the direction of the wind. (*See* Appendix I, Section B.)

(ii) *Wing-tip flares* form part of the equipment of every night flying aeroplane and are provided for use in the event of a forced landing. The flare is carried in a special bracket fitted to the under-side of the lower plane near the wing-tip and is ignited electrically, being switched on from a convenient position in the cockpit. When required the flares are usually lit at an altitude of 800 to 1,000 feet.

(iii) *Reconnaissance flares* are provided primarily for night reconnaissance. They may also be used to assist a pilot in selecting a landing ground when making a forced landing. Although there are several different types of reconnaissance flare in use in the service, they are all constructed on the same main principles and consist of four main parts :—

(*a*) Case.
(*b*) Igniter or fuse.
(*c*) Candle unit.
(*d*) Parachute.

On the flare being released the igniter or fuse is operated automatically by electrical or mechanical means, and after a few seconds delay to allow the flare to fall clear of the aircraft,

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the case is burst by a powder charge; the parachute and candle unit is ejected and at the same time the candle unit is ignited.

Inter-communication

16. An efficient system of inter-communication at night, between pilots and ground personnel, is of primary importance; the success of an operation and the safety of a pilot is to a large extent dependent on the speed and accuracy with which instructions can be received and information conveyed between pilot and aerodrome. The methods available for communicating between aircraft, and between aircraft and the ground, are:—

(i) Wireless telephony.
(ii) Wireless telegraphy.
(iii) Signal lamp.
(iv) Signal cartridges.

17. Wireless telephony and telegraphy are generally employed for long flights, but should invariably be supplemented by visual signalling in an emergency or in the vicinity of the aerodrome. The visual signals used for night flying are given in Appendix I; but are subject to change when secrecy is necessary.

Elementary Training in Night Flying

18. Before commencing night flying training a pilot must, in the opinion of his unit commander, be a reliable pilot and must have at least five hours' flying experience on the actual type of aircraft which he will be expected to fly at night. Unit commanders may commence the night flying training of pilots when qualified as above and when considered fit, but a flying experience of forty hours on the squadron type of aircraft or allied types should be aimed at in the case of young and inexperienced pilots.

19. A pilot should only fly at night on that particular aeroplane which is allotted to his use by day.

20. Instruction should commence with one or two night flights as a passenger, *without dual control* (*see* note hereunder), so as to enable the pupil to visualise the conditions at night.

Note.—Dual control instruction at night may be given in the case of large night bombers on which much work is entailed by the necessary inspection or repairs after a heavy landing, but the dual control should be as little as possible.

21. Before commencing night flight training the pupil should be practised in landing along a dummy flare path on the aerodrome to teach him:—

(i) The correct approach to the flare path.
(ii) The correct use of signals.
(iii) The handling of aircraft on the aerodrome, *i.e.*, when in the flare path, when approaching, and when leaving it.

22. The pupil should then be sent up half an hour before dusk and should make a series of landings along the lit flare

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path; this will gradually accustom him to the conditions of landing at night by progressive stages of darkness.

23. From this it is a short step to landings with aerodrome flares, first on moonlight and then on dark nights; thence to landings by means of wing-tip flares only.

24. When the pupil is proficient in night landings, he should be given short cross-country flights to neighbouring aerodromes, at first without landing at the aerodrome.

25. At no time must a pupil carry out a landing by night on an aerodrome on which he has not landed by day; the landing by day should, whenever possible, immediately precede the landing by night.

Advanced Training in Night Flying

26. When a pilot's elementary night flying training has been completed he should be practised in long cross-country flights, landing at aerodromes *en route*.

27. Cross-country flights should be carried out at specified altitudes and practice should be given in flying high by means of instruments only as well as in flying at a low altitude and finding the way by recognition of ground features.

28. Pilots should, whenever possible, study by day the country over which they will fly by night, so that when selecting their landing ground in an emergency at night they may be guided by the knowledge gained during the daytime.

29. The ultimate aim of advanced training is to approximate as closely as possible to the conditions which will prevail in time of war. Advanced training should, therefore, be carried out with the minimum lighting practicable, consistent with the skill and standard reached by the pilots concerned.

Night Flying Regulations

30. "Standard Orders for Night Flying at Royal Air Force Aerodromes" will be found at Appendix I of this manual.

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CHAPTER II

AIR DRILL

(*See also* "PROVISIONAL MANUAL OF AIR DRILL")

FUNDAMENTAL PRINCIPLES

Introductory remarks

1. The offensive and defensive qualities of a concentration of aircraft depend almost entirely upon its organisation and upon the effective concerted action of its units. A compact, well-drilled formation can resist attack from superior forces, and can penetrate to objectives deep in the enemy's territory in the face of large concentrations of enemy aircraft.

2. The closest co-operation between the pilots of a formation is necessary to efficient collective flying, and is only attained by continual practice. An air formation is not a heterogeneous assembly of aeroplanes flying together, but must be an organised unit composed of individuals accustomed to work together, flying their craft in definite positions relative to each other, their movements directed by a single leader and their whole formation capable of manœuvring and fighting in the closest cohesion.

3. The primary objects of formation flying are :—

(i) Concentration for offensive action, either for air fighting or for combined attack upon enemy objectives with bombs, torpedoes or machine-gun fire.

(ii) Mutual support. No aircraft has yet been designed which possesses a uniformly efficient all-round field of fire; but a formation should be so organised as to eliminate blind spots and enable fire to be concentrated in any direction.

(iii) Moral advantage. Both in the attack and defence, the moral effect upon an enemy of a well-drilled formation is far greater than that produced by a number of isolated aeroplanes. Further, the confidence that pilots possess in their leader, and the consciousness they have of being supported by others upon whom they are accustomed to rely, increases their *moral*.

4. The success of formation flying in battle depends upon :—

(i) Leadership. Good leadership requires balanced judgment, initiative and courage, combined with unselfish devotion to duty.

(ii) Discipline. The practice of instant obedience to the directions of a leader, and the habit of spontaneous action for the advantage of the formation rather than of the individual.

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(iii) Drill. Skill in combined manœuvre, in retaining formation under difficult circumstances, and in re-forming rapidly after dispersal.

(iv) Fire tactics. This comprises skilful control and direction of fire by the leader, combined with careful aim and economy of ammunition by the formation. It demands concentration of fire at successive enemy aeroplanes.

Factors governing the disposition of aeroplanes in formation

5. Although the distribution of aeroplanes in a formation will vary according to the duties to be performed, the type or types of aeroplanes employed and other considerations, certain principles are fundamental, and must be strictly observed. These are :—

(i) A formation is commanded and led by a pilot who is immediately responsible for its security, for the course flown, and for the tactics adopted.

(ii) The leader of a formation must be replaceable by a deputy leader, who flies in a definite and pre-arranged position relative to the leader, and must be prepared at any time to take the place and assume the responsibilities of leader.

(iii) The leader must fly in a position from which he is visible to all his pilots, or in large formations to leaders of all sub-formations.

(iv) The aeroplanes of the leader and the deputy leader must be designated either by streamers or by some other device which can be easily recognised. (*See* para. 14 of this chapter.)

(v) The leader should be able, by turning his head, to see all his pilots, and ascertain at any time whether they are in their respective positions.

(vi) No pilot should be stationed directly behind another, since in this position the slipstream of the aeroplane ahead would make it difficult for him to keep station, and his field of fire would be largely obscured.

(vii) The organisation of the formation must be simple, easily adopted and easily retained; the fundamental principle being that, in the event of the leader or any other pilot becoming a casualty, his station can be filled with least disorganisation and minimum delay by another pilot.

(viii) The formation must be flexible; capable of opening out or closing in on the leader, and of changing to a different formation when necessary.

6. The duties for which formation flying is employed are various, but can be classed roughly in two categories, *i.e.* :—

(i) Offensive action, aimed directly at the destruction of the enemy's aircraft.

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(ii) Duties not directly connected with the destruction of hostile aircraft, but which comprise offensive action against other objectives and may be sub-divided into :—

(*a*) Bomb raids.
(*b*) Low flying attack against ground objectives.
(*c*) Reconnaissance patrols.
(*d*) Escorts.

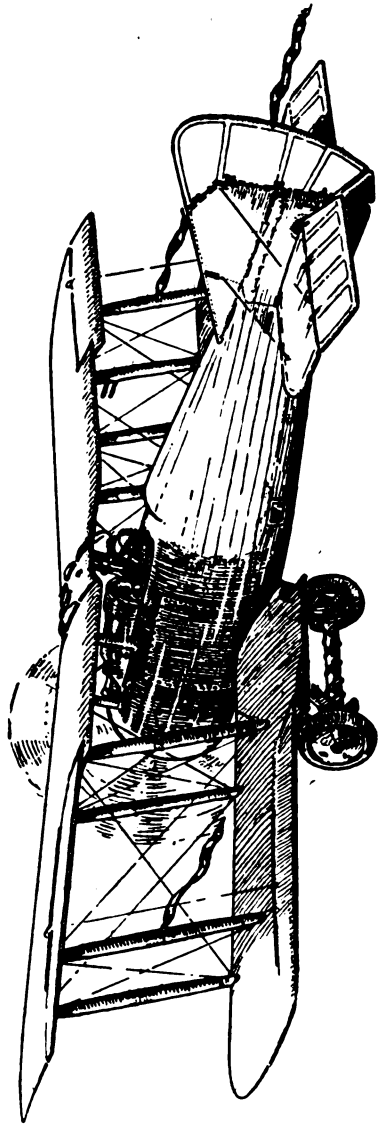

FIG. 2.—STREAMERS FLOWN BY THE LEADER OF A FORMATION.

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7. Formations are termed close or open.

8. It should be borne in mind, when flying in close formation, that the nearer pilots can fly to one another and to their leader without undue strain, the more readily are they controlled, the more effectively can they concentrate fire against a common objective, and the more easily can they afford each other mutual support.

9. Open formation may be adopted by fighting aeroplanes for tactical reasons or because of the weather conditions, but it is more often resorted to when flying large aeroplanes or seaplanes of the multi-seater type, which are heavily armed and require considerable space in which to manœuvre.

10. In air drill, pilots will be taught to form close formation from open formation and *vice versâ* with rapidity and precision.

THE SUB-FORMATION

General Principles

11. As already pointed out the disposition of aircraft in formation is influenced by a number of factors; but all formations, however large, are composed of sub-formations the organisation of which is fixed.

12. Though an air formation may be highly trained and led by a skilful commander, difficulty will often be experienced in retaining formation during a severe engagement; especially is this so where large numbers are engaged on either side, or when a succession of leaders become casualties.

13. This difficulty is, to a large extent, overcome by organising all formations into a number of smaller groups or sub-formations, the pilots of which are trained to fly and fight in the closest co-operation. Thus a large formation working under a single leader may be composed of a series of self-contained sub-formations, capable of independent action should necessity arise.

14. The leader of a formation flies a streamer from each rear outer strut and one from his rudder. (*See* Fig. 2.) The leader of a sub-formation flies a streamer from his starboard rear outer strut, and one from his rudder. (*See* Fig. 3.) The deputy leader of a formation flies a streamer from each rear outer strut, but none from his rudder. The deputy leader of a sub-formation flies a streamer from the starboard rear outer strut, but none from his rudder. (*See* Fig. 3.) Streamers should indicate by colouring to what unit the pilot belongs.

15. Aircraft in formation are numbered from starboard to port,—even numbers being to starboard, odd numbers to port of the leader.

16. The flight is normally the tactical sub-formation. The strength of a flight is from four to six aeroplanes. Pilots should therefore be trained to fly in sub-formations of any number from three to six. In peace, however, as the strength of a flight of single-engine aeroplanes is four, and as the percentage of aeroplanes continually serviceable will normally be 75 per cent., the sub-formation of three aeroplanes is usually employed.

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The Flight Sub-formation.

17. In this formation, the leader No. 1, is followed by pilots 2 and 3, who keep station astern and on either quarter. Pilots Nos. 2 and 3 may fly at the same level as their leader, or slightly above him, according to the type of aircraft in use, provided they keep so close to him that they can recognise his signals and follow him through any manœuvre without losing station. Pilot No. 2 invariably acts as deputy-leader and generally flies on the leader's starboard quarter, though for purposes of manœuvre he may, on occasion, be required to change his position to port.

18. The smaller the formation, the greater is its power of combined manœuvre. The sub-formation of three, therefore, possesses the maximum power of manœuvre. On the other hand it obviously develops less fire power than sub-formations of four, five or six aeroplanes and is proportionately more liable to be overwhelmed by superior numbers.

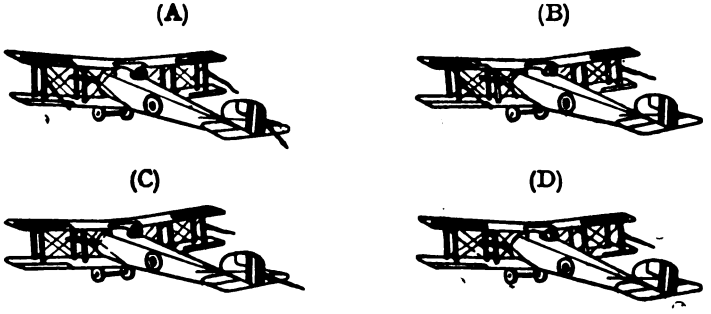

FIG. 3.—STREAMERS FLOWN IN FORMATION.

(A) Leader of formation.
(B) Deputy leader of formation.
(C) Leader of sub-formation.
(D) Deputy leader of sub-formation.

19. A squadron consisting of three flights is thus divided into three sub-formations, each sub-formation being led by its flight commander or senior pilot.

20. In the event of one of the pilots of a sub-formation of three becoming a casualty, the senior remaining pilot followed by the other should endeavour to join on to another sub-formation at the earliest opportunity, each pilot taking up his station on the quarter of and slightly above No. 2 or No. 3 of the other sub-formation.

ELEMENTARY TRAINING

General Principles of Training

21. Training in air drill should be directed towards teaching the pilot how to work in combination with others, and to develop in him such a high state of efficiency in flying that in

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the stress of battle, whilst flying and maintaining his station subconsciously, he will be able to devote his whole attention to the use of his weapons, and to manœuvring according to the directions of his leader. Air drill requires careful training and constant practice to produce cohesion and the habit of instant obedience to a leader.

22. Instructors should bear in mind that a formation, though apparently perfect when manœuvring over the aerodrome, will have its cohesion put to a severe test when flying under heavy fire, or when re-forming after a long and punishing engagement. Training in air drill should, therefore, continue until each pilot maintains his position in formation instinctively and subconsciously.

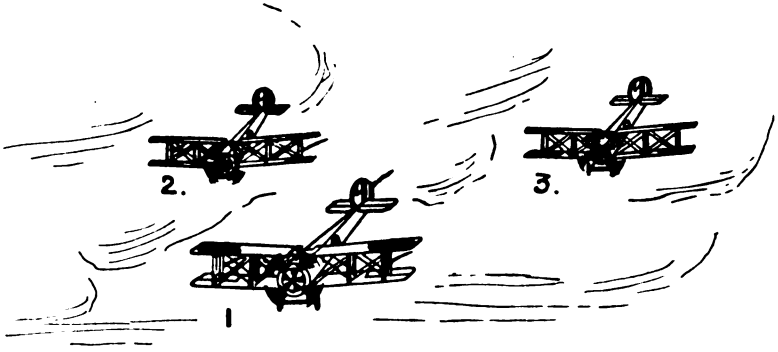

FIG. 4.—FORMATION OF THREE.

23. (i) The preliminary training of pilots should aim at developing :—

(*a*) Confidence to fly in close proximity to other aircraft.

(*b*) Ability to maintain station.

(*c*) Vigilance, *i.e.*, the faculty of observing the leader's signals, and at the same time recognising the approach of any other aircraft.

(*d*) Efficiency in flying drill, since in the air, as on the ground, the basis of successful co-operation is drill.

(ii) When satisfactory progress has been made in these essentials, pilots should be taught how to apply what they have learnt to the varied conditions which they may encounter in war.

24. Training should be progressive, beginning with the training of the smallest sub-formation (*see* paras. 17 to 20), and continuing with the training of the successively larger sub formation and units; the object of the training of each sub-formation or unit being to fit it to take its place in the next higher sub-formation or unit.

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Ground Instruction

25. Ground instruction forms the basis of elementary training, and should consist of lectures illustrated by drawings, models and photographs; it should include the following subjects :—

(i) *Discipline.*—Discipline both on the ground and in the air, including punctuality and instant obedience to all commands of the leader.

(ii) *Use of the throttle in maintaining position.*—One of the first essentials to success in formation-flying is that every pilot should thoroughly understand how to use his engine throttle. He will find it necessary to use it constantly throughout a flight, and must train himself to do so instinctively.

(iii) *Types of formation.*—The pilot should be taught the types of formations laid down in the Provisional Manual of Air Drill.

(iv) *Choice of position.*—The advantages and disadvantages of various stations in formation should be explained by means of models. It should also be pointed out that a pilot must never fly in the following positions :—

(*a*) Directly behind another aircraft (*see* para. 5 (vi) of this chapter).

(*b*) In the " blind " spot of the leader.

(*c*) In any position from which he cannot see the leader.

(v) *Intercommunication* (*see* paras. 26–29 below).—Pilots should be taught all elementary signals, methods of communicating by signal cartridge, and the use of the wireless telephone. It should be pointed out how essential it is to avoid all unnecessary communications, and that all signals should be given clearly and precisely.

Intercommunication

26. The value of an efficient method of communication between the leader and the remainder of the formation is manifest. All pilots and observers should be familiar with the use of the wireless telephone, which should, however, be supplemented by a simple code of signals for use in an emergency.

27. Signal cartridges may also be used when wireless telephony is not available. When communication is maintained by means of signal cartridges the undermentioned signal should be

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used; these signals should not be departed from except by pre-arrangement with the object of deceiving the enemy.

Signal.	Signification.
(1) One signal cartridge, RED.	"I am forced to return to my aerodrome." (If fired by the leader, the leadership must be taken over by the deputy leader.)
(2) One combined signal cartridge, WHITE followed by GREEN.	"Flight is abandoned. Return to aerodrome." (Fired by the leader to his formation.)
(3) One signal cartridge, GREEN.	"Enemy aircraft in sight."

28. Further signals or combinations of signals by signal cartridges may be devised to meet requirements.

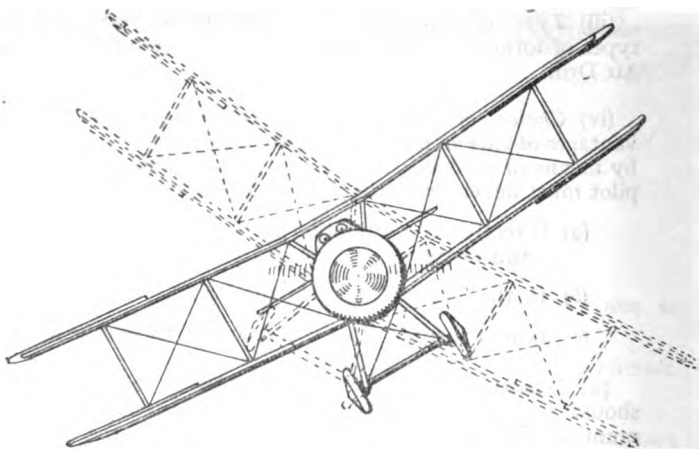

FIG. 5.—SIGNAL FOR "CLOSE UP."

29. When pilots are flying in "close formation," certain elementary signals are used to supplement other methods of inter-communication. These are:—

(i) "*Close up.*"—Leader rocks his aeroplane laterally, banking gently and rapidly first to one side then to the other. (*See* Fig. 5.)

(ii) "*Open out.*"—Leader rocks his aeroplane violently fore and aft. (Used also as a preliminary signal to the about turn.") (*See* Fig. 6.)

(iii) "*About turn.*"—Leader pulls the nose of his aeroplane up gently and then resumes level flight (*see* Fig. 10). (Used by leader to warn his formation that he is about to

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half roll; the "open out" signal is given first.) (*See* Fig. 6.)

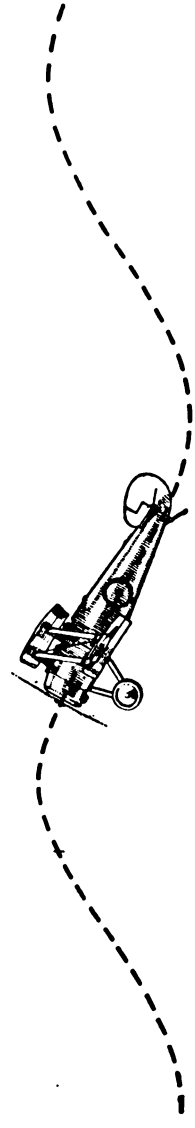

FIG. 6.—SIGNAL FOR "OPEN OUT."

(iv) "*Change direction* (steep turn)."—Pilot banks twice in the required direction without turning. (Used by leader to warn his formation that he is about to turn.) *See* Fig. 8.)

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(v) "*Enemy in Sight.*"—Leader rocks his aeroplane laterally several times, banking steeply and slowly first to

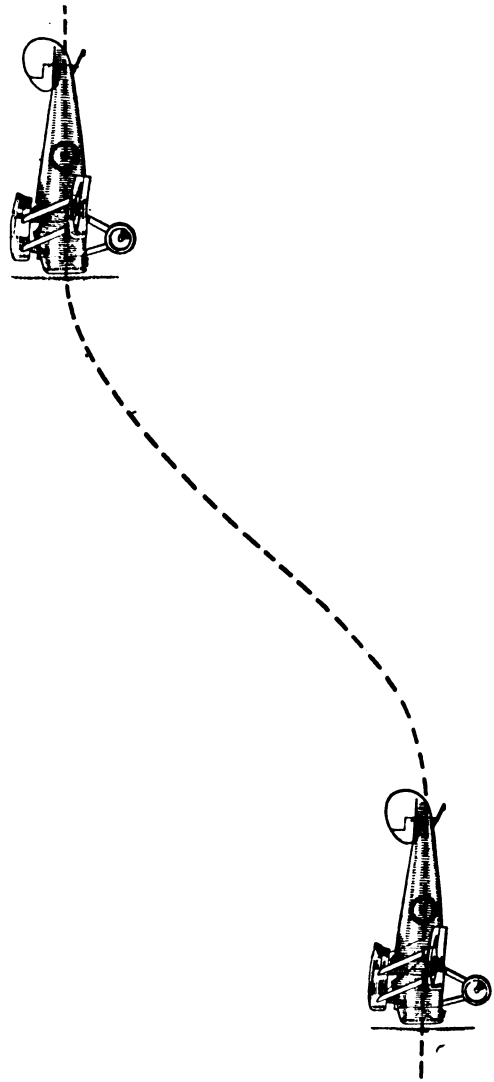

FIG. 7.—SIGNAL FOR "PREPARE TO DIVE."

one side then to the other. This signal may be made by any pilot as a warning to others that hostile aircraft are in sight. (*See* Fig. 9.)

(vi) "*Prepare to dive.*"—Leader lowers the nose of his aeroplane slowly, then flattens out again and carries on at the same level. (*See* Fig. 7.)

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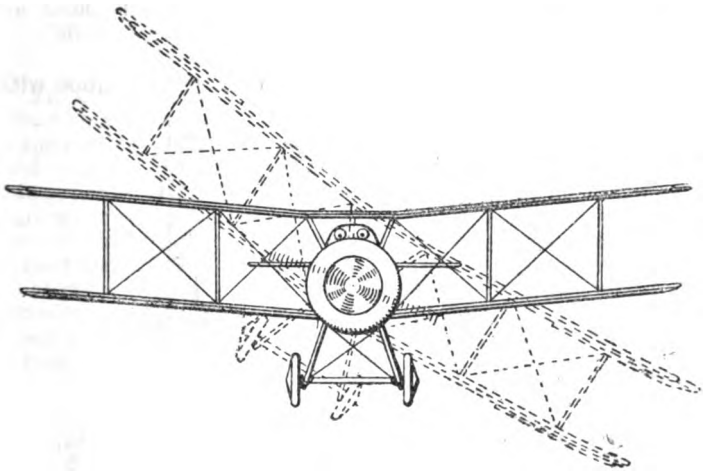

FIG. 8.—SIGNAL FOR "CHANGE DIRECTION."

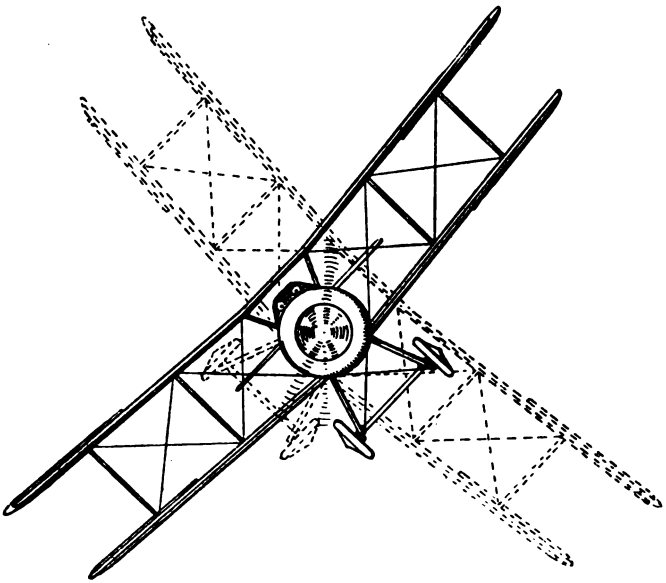

FIG. 9.—SIGNAL FOR "ENEMY IN SIGHT."

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Preparations before the start

30. Before starting on a flight the leader should collect his pilots and explain clearly and precisely to them :—

(i) The object of the flight.

(ii) The time at which pilots are to be in position with

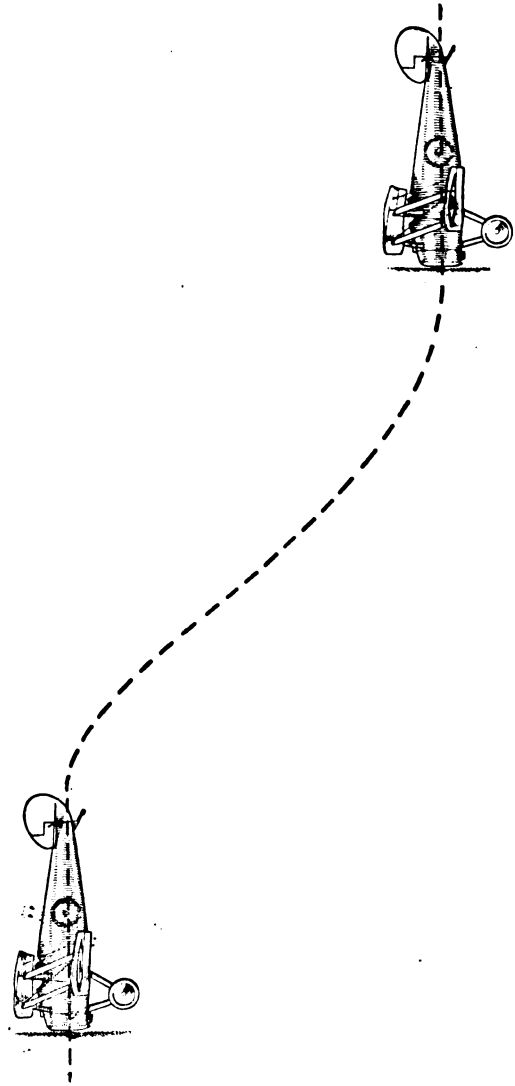

FIG. 10.—SIGNAL FOR "ABOUT TURN."

their engines running. (N.B.—This will normally be five minutes before the time of the start; but will depend on the type of engine and the method of getting away.)

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(iii) The method of taking off.
(iv) The position of individual pilots for taking off.
(v) The type of cruising formation to be adopted in the air and the exact position of each individual pilot.
(vi) Special signals to be employed.

31. Discipline on the ground during preparations for a start is just as necessary as it is in the air. Even in the initial stages of instruction, definite orders should invariably be issued giving time of start and composition of formation, so that pilots may cultivate the habit of punctuality. The hour detailed for the start must be the time at which the leader is actually to leave the ground; at that time the remainder of the formation must be in their respective positions, ready to take off. The time required to complete the necessary preparations for a flight will vary according to circumstances; but pilots should be on the aerodrome at least half an hour before the time detailed for the start, so that they may :—

(i) Carry out a final inspection of their aeroplanes.
(ii) Check armament and ammunition.
(iii) Prepare maps and equipment, and put on their flying clothing.

Getting into formation

32. The methods of forming up vary according to circumstances, but may be classed under two headings :—

(i) Getting off in formation, and
(ii) Forming up in the air.

33. "Getting off in formation" is the most satisfactory method, especially for single-seater aeroplanes, and is comparatively easy provided that the aerodrome is not surrounded by obstacles. Pilots taxi to their allotted stations, head to wind, and, as soon as they are ready to take off, hold up their hand, as a signal, and look towards the leader; the latter waits until he receives the "All clear" signal from the aerodrome officer or senior N.C.O. in charge, waves his extended hand above his head so that all pilots can open their throttles together, opens up his throttle and takes off, followed by the remainder of the formation. The leader should fly straight ahead, and should throttle down as soon as he has attained the height of a few hundred feet so as to allow the formation to close up, before he attempts a change of direction.

34. The method of "forming up in the air" has to be resorted to for large aeroplanes or when the aerodrome in use is of limited size and surrounded by obstacles. The start should invariably be controlled by an aerodrome officer, who should signal to each pilot in turn when he is to take off. The leader takes off at the time appointed for the start and, having gained sufficient height, throttles down and flies in large circles round the aerodrome. The remaining pilots take off successively as arranged by the officer in charge, and take up their pre-arranged position

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in formation as rapidly as possible. As soon as the formation is satisfactory, the leader gives the signal for departure, and flies off in the desired direction, throttling down to allow any stragglers to close up.

Formation by "Rendezvous"

35. Successful forming up by "rendezvous" depends largely on the issue of clear and concise orders, which should include the following particulars :—

(i) Time of rendezvous.
(ii) Location of rendezvous, *i.e.*, the map reference of the place over which the rendezvous is to take place.
(iii) Altitude at which the leader will be flying at the time detailed for the rendezvous.
(iv) Class of formation and station of each individual pilot; or, if the formation is to consist of a number of sub-formations, altitudes and stations of sub-formations.
(v) Special signals to be used.

36. The leader must leave the ground in time to be at the rendezvous five minutes before the appointed time; and, as soon as he arrives, should throttle down and fly in wide circles, without, however, allowing his aeroplane to drift down wind away from the position.

37. Individual pilots leave the ground independently and are responsible for being at the rendezvous at the appointed time; they should reach the vicinity of the leader before the time of rendezvous and climb to a slightly higher altitude, so that by increasing their speed they can more easily take up their stations. If the formation is made up of sub-formations, subordinate leaders will act independently and are responsible for bringing their formations to the rendezvous at the correct time.

38. It is advisable to select some easily distinguishable landmark as the spot over which the rendezvous is to take place, as this will minimise delay, especially during unfavourable weather conditions.

39. This method of forming up in the air should be practised until proficiency is attained, since upon it is based the reorganisation of a unit during and after an engagement.

40. A spare pilot may be detailed to fly to the rendezvous with instructions to replace any casualty that may occur before the start. This pilot flies astern of the formation and at a higher altitude, until the leader passes a definite point on the flight, after which, if not required to replace a casualty, the spare pilot will return to his aerodrome.

Keeping Station

41. During their early training, pilots should be taken up in a formation of three, until they overcome the disinclination to flying in the vicinity of another aeroplane, and acquire the habit of conforming instantly to the movements of a neighbouring pilot.

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42. As pilots progress, the instructor, acting as leader, should occasionally vary his speed until pupils can maintain their correct station under varying conditions. Straggling should never be allowed, even during the initial stages of training, as efficiency in the attack and security in defence depend on the maintenance of station by each pilot. A pilot who lags behind the remainder of the formation not only runs the risk of being cut off himself, but endangers the lives of others by greatly adding to the difficulties of the leader.

Changing direction

43. When proficiency in keeping station while flying on a straight course has been acquired, the instructor should explain the procedure adopted in turning, and demonstrate any cautionary signals he may use before altering course.

44. Instruction should begin with gentle turns which should be carried out without a change in the relative positions of pilots. No change of direction should be initiated by the leader without first giving a cautionary signal so as to allow the formation to close up. A simple turn is carried out in the following manner. The leader gives the cautionary signal as in para. 29 (iv), and, after allowing the formation time to close up, turns in the required direction. Pilots flying on the inner flank of the turn, throttle down and reduce their speed, while pilots flying on the outer flank accelerate and maintain their station if necessary by loss of height, though if this occurs they should climb back into their places on completion of the turn. The leader should continue to fly at normal cruising speed until the turn is completed and the formation closed up. (*See* Fig. 11.)

45. An alternative method of turning, suitable for a "flight vic" formation is carried out as follows. As soon as the leader turns, the two pilots astern of him exchange stations by crossing and taking post on opposite sides. With a formation of five aeroplanes the same manœuvre is carried out simultaneously by the two rearmost pilots. The pilots on the inner flank of the turn should cross by passing over those on the outer flank, thus enabling the latter to maintain their stations by increasing speed. (*See* Fig. 12.)

46. A method of turning about sometimes used by fighting formations is shown in Fig. 13. The leader turns to port, the remaining pilots execute a quick turn outwards.

47. When pilots have attained proficiency in keeping station through all simple manœuvres, the number of pilots taking part in the formation may be increased, and exercises in diving and climbing, and in breaking up and reforming, should be begun.

48. Towards the end of a pupil's early training in air drill the petrol consumption of his engine should be checked and compared with that of the instructor. This should be done especially when high flying is being practised, since accurate use of the altitude control will reduce petrol consumption and thus lengthen the working range of a patrol.

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ADVANCED TRAINING

General Remarks.

49. The object of advanced training is to render flights, squadrons and larger formations capable of manœuvre in battle.

50. The instruction of individuals in flying, air fighting and in elementary air drill should not be considered as limited to certain definite periods; advantage must be taken of any opportunities which may arise during advanced collective training to raise the standard of efficiency of pilots by individual tuition. Special attention should be paid to the training of subordinate commanders.

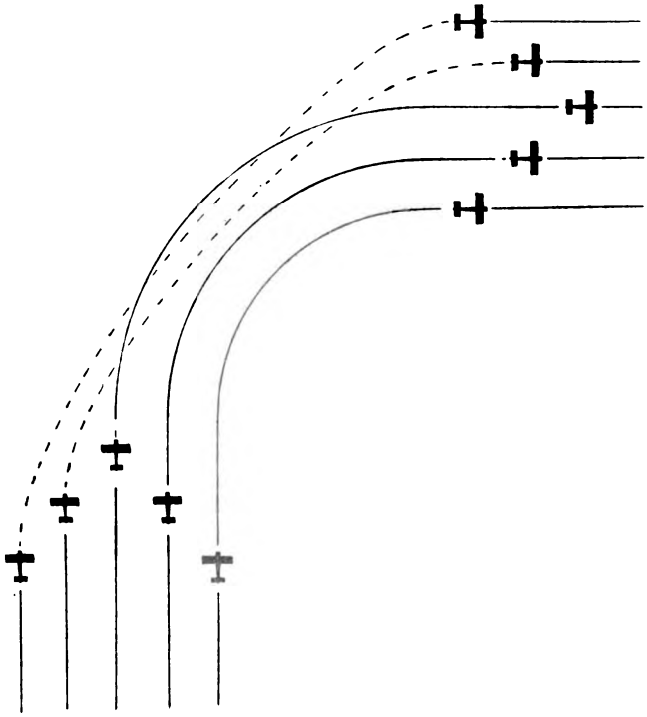

FIG. 11.—A SIMPLE TURN.

Formation Leadership

51. The usefulness and ultimate success of a formation depends to a large extent on the skill and conscientiousness of its leader and on the confidence he inspires. The power of good leadership can be acquired, to some extent, by practice and experience; and it is therefore of the utmost importance that instructors should frequently arrange to be replaced by other pilots during

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a flight. Thus, while the pupil gradually acquires the experience and confidence necessary to good leadership, the instructor without actually taking part in the formation, can fly in its vicinity so as to be able to criticise the leader's manœuvres.

52. It should be explained that the responsibilities of a leader do not end with placing himself in front, for others to follow, but combine the duties of a commander with those of a guide. He is responsible, not only for maintaining direction and for deciding when to return, but for regulating his speed by flying and manœuvring judiciously, so that the formation will have no difficulty in maintaining its cohesion. He should keep constant watch over his formation, and regulate his speed by that of its slowest member.

53. Intimate co-operation between the leader and his pilots is essential to success, and is best assured by the development of that mutual confidence which springs from constant practice and association together. The growth of mutual confidence will be expedited if the leader :—

(i) keeps constant watch over his pilots;
(ii) always issues a cautionary signal before initiating a fresh manœuvre;
(iii) never loses his way:

and if the remaining pilots of the formation :—

(i) always watch for the leader's signals;
(ii) carry out all orders promptly;
(iii) keep station.

54. Perfect co-operation can only be attained after a great deal of practice; no opportunity should therefore be neglected of training a unit under conditions resembling, as nearly as possible, those of war.

55. The first duty of a leader is to appoint a deputy leader whose aeroplane will bear distinctive markings. (*See* para. 14.) The deputy leader must be familiar with the duties and intentions of the leader, so that, in the event of the latter becoming a casualty, the formation will be able to continue its work without loss of efficiency. The actual position of the deputy leader in the formation with relation to the leader will depend largely on the disposition of the remaining pilots; the fundamental principle being that, if the leader is compelled to fall out, the deputy-leader should be able to reach his new station as rapidly and as easily as possible. Any consequent alteration necessitated in the respective stations of other pilots should be reduced to a minimum.

56. Although the rate at which a leader should fly varies according to the requirements of the moment, it will necessarily be limited to the speed of the slowest aeroplane in the formation. The leader should never reduce his speed to such an extent that pilots flying astern of him will have difficulty in maintaining their stations without overshooting. He should also bear in mind that while he sets his own pace, the other pilots have to

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increase and decrease speed continually; and, therefore, he should endeavour to fly at a mean rate between full level speed and stalling speed. He should give his pilots due warning of any change of course, and never turn more suddenly than is absolutely necessary. It is important that a leader should himself

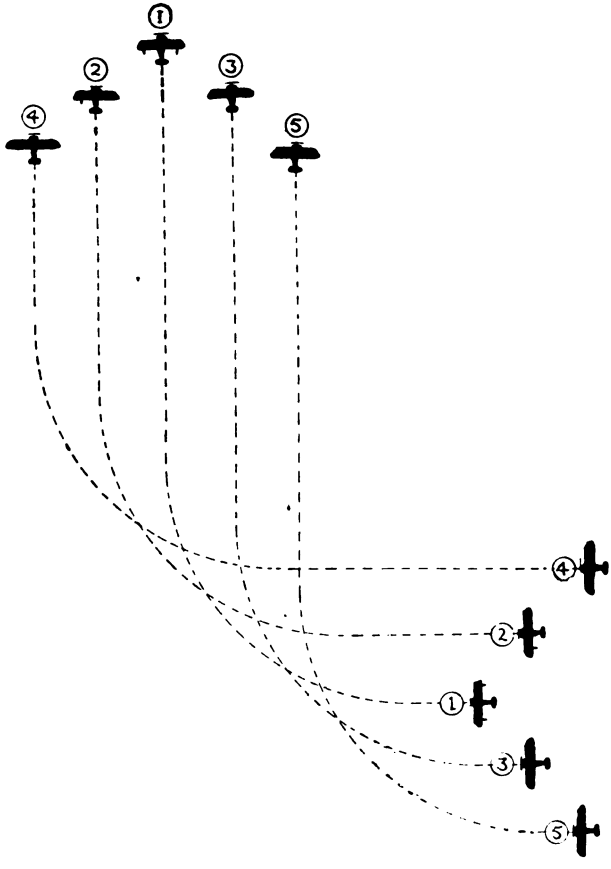

FIG. 12.—TURNING (CROSSING OVER).

have had experience of flying in all the various positions of the formation so that he may realise the difficulties of his pilots. Frequent discussions should take place at which the leader should explain his reasons for adopting various formations and should encourage other pilots to make alternative suggestions.

Air Drill

57. Before attempting to carry out an evolution in the air, pilots should be thoroughly acquainted with the various phases

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of the movement. With this object in view the instructor should place the pilots of the formation he is instructing in positions on the ground similar to those they will adopt in the air, and cause them to carry out, as far as possible on the ground, with a standard infantry pace and step, the movements they will be

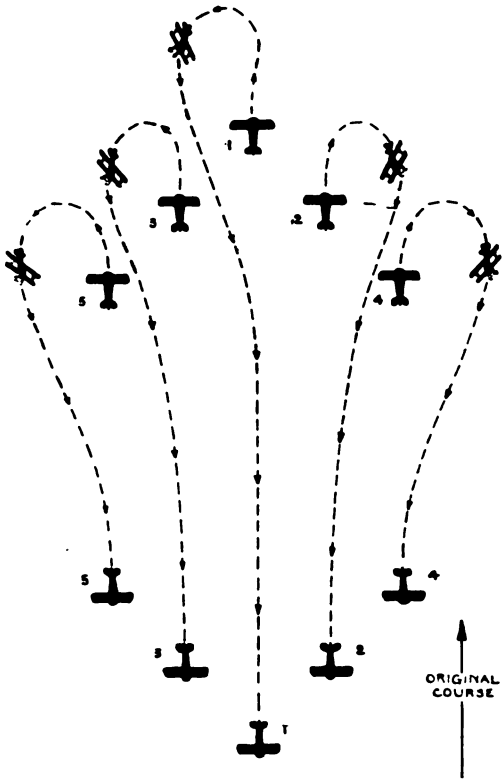

FIG. 13.—TURNING ABOUT.

called upon to execute with their aeroplanes. In this manner pilots become familiar with their positions and more readily fall into place in the air.

58. Drill should commence in flight formation, each flight commander instructing and leading his own flight: it should aim primarily at developing discipline, cohesion, and the habit of instant obedience to the signals of the leader.

59. The practical training of flight commanders in leading their flights when acting as sub-formations is of supreme importance, and, with this object in view, a flight should be regarded as a distinct unit, commanded throughout its advanced training

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by its own leader. The flight commander is, however, responsible that all the pilots of his flight receive ample practice in leadership to qualify them to take his place if necessary.

60. When flights have become efficient in elementary drill, they should be trained in the more complicated manœuvres required in war: this training should include :—

(i) Taking off in formation, and keeping station during a climb up to 15,000 feet with full war-load.
(ii) Diving in formation.
(iii) Scattering and re-forming close formation.
(iv) Forming circle from close formation and *vice versâ*.
(v) Opening and closing formation.
(vi) Flying through clouds in open formation.

61. In war, the distances and intervals between aircraft will depend principally on the duty in hand and the tactical situation: it is, therefore, important that pilots should be taught to manœuvre both in open and close order.

62. Concurrently with this stage of training in the air, lectures should be delivered on the following subjects :—

(i) Use of patrols.
(ii) Co-operation in the air.
(iii) Advantages and disadvantages of different formations.

The Patrol

63. When individual pilots are sufficiently trained in air drill and in the elementary principles of air fighting (*see* Chapter III), squadrons and flights should be sent into the air to carry out definite schemes to illustrate various phases of air warfare. Each scheme should exemplify some particular principle, and be designed to teach some definite lesson, which should be explained beforehand at a short conference held on the ground. Simplicity is essential, since complicated manœuvres are liable to fail in action. Each pilot should be given definite instructions as to time of start and composition of patrol. Special attention should be paid to the training of leaders in grasping and dealing rapidly with situations; and to the reforming of formations after they have become disorganised and their leaders incapacitated. Patrols should approximate, as far as possible, to service conditions; and pilots should not be allowed to employ during peace operations methods which would be impossible in war.

64. At the conclusion of each flight, a conference should be held at which it should be shown how far the principles, referred to in the preliminary conference, have been successfully applied to each situation, where these principles have been violated, and how faults can be avoided in future. It should be pointed out that the outstanding essential of a successful patrol is, that it should retain its cohesion under all circumstances; and that stragglers are a danger not only to themselves, but to the formation as a whole.

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65. As explained previously, there are various methods of assuming formation; but, unless the situation demands otherwise, a patrol will leave the ground in formation; or, at any rate, pilots will leave the ground in rapid succession and close on the leader as they gain height.

66. The start should usually be controlled by an aerodrome officer whose duties will include the following :—

(i) Arrangements for clearing the aerodrome.
(ii) Indicating the position from which each aeroplane is to start.
(iii) Ascertaining whether the leader and all other pilots are ready to start.
(iv) Giving the signal to the leader that all is ready for the start.
(v) When pilots leave the ground individually to form up in the air, giving the signal for the start to each pilot in turn.

67. In forming a decision as to the final disposition of his pilots, the patrol leader will be guided by his personal experience of the type of aeroplane being flown and by the necessity of arranging his formation so as to avoid blind spots.

68. Before sending up a patrol, the leader should be given precise instructions as to :—

(i) The duties of the patrol.
(ii) The part of the country to be treated as "occupied by hostile troops."
(iii) The area over which the patrol is to operate.
(iv) The time at which the patrol is to return to the aerodrome.

69. After receiving his instructions, the leader should collect his patrol and explain his plan of action; so that, if he has to leave the patrol, for any reason, its mission may not be interfered with.

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CHAPTER III

AIR FIGHTING

GENERAL CONSIDERATIONS

Introductory remarks

1. The struggle for superiority in the air takes the form, as in other fighting, of a series of combats; and it is by the cumulative moral and material effect of a sequence of successes, that ascendency over the enemy is gained.

2. Air superiority can only be established by pursuing a policy of relentless and incessant offensive against the enemy's air forces in the air and on the ground.

Fundamental principles

3. No definite rules can be laid down for air tactics, since they must vary according to the individual characteristics of the pilot and the type of aircraft which is employed; but there are certain fundamental principles upon which air fighting is based. These are :—

(i) *Victory can only be achieved by a display of the true offensive spirit.*

(ii) *Every attack must be driven home with implacable determination to destroy the opponent.*

(iii) *Surprise must be employed whenever possible.* The principle of surprise is applicable not only to attack from unexpected directions and at unexpected times, but also to methods of attack.

Factors which affect success

4. The fighting efficiency of aircraft depends :—

(i) On the qualities of the pilot (and of the gunner or gunners in two-seater or multi-seater aeroplanes), *i.e.* :—

(*a*) *Morale.*

(*b*) Good physical condition.

(*c*) Skill in flying and in the use of his weapons, and a thorough understanding of the capabilities of his aircraft.

(*d*) In two-seater or multi-seater aeroplanes, on the perfect understanding between pilot and gunner who must fight as one mind.

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(ii) On the qualities of the aircraft, *i.e.* :—
(*a*) Speed and climb.
(*b*) Ceiling.
(*c*) Armament and field of fire.
(*d*) Power of manœuvre.
(*e*) Field of view.

5. The fighting characteristics of aeroplanes vary according to type, thus :—

(i) *Single-seater aeroplanes* must possess speed, climb and manœuvring power. Owing to their limited size, they are more difficult to recognise from a distance and are therefore essentially the craft for surprise attack and for offensive action. They are capable, however, only of attack, as they are not generally fitted with armament aft and, consequently, are liable to be taken by surprise. In defence, they are dependent on their handiness, speed and power of manœuvre. They are at a disadvantage as regards armament when opposed to a hostile two-seater; and, therefore, the moment they cease to attack, are in a position of inferiority and must break off the combat temporarily, until they have regained a favourable position for attack. On the other hand, provided they are superior in speed and climb to their adversary, they possess the advantage of being able to break off the combat at will when necessary.

(ii) *Two-seater aeroplanes*, when constructed for fighting, possess many of the qualities of the single seater. The two-seater aeroplane is fitted with one or more fixed guns which fire forward and are for the use of the pilot, while the observer is armed with one or more guns mounted so as to allow as wide a field of fire as possible, especially astern. The two-seater is superior in armament to the single-seater, since it is capable of all-round fire; but it is generally somewhat inferior in speed, climb and power of manœuvre. It is capable of sustaining a prolonged combat and is less liable to be surprised. As in the single-seater, its chief strength lies in attack; but its value will depend largely on the skill, vigilance and determination of the gunner, and on the co-operation between him and the pilot.

TRAINING

General remarks

6. All commanders, from flight commanders upwards, are responsible for the training and efficiency of their commands, both in war and peace.

7, The squadron commander is responsible for the training of his squadron as a whole, and for the efficiency of his flight commanders, not only as commanders but as instructors. He must train his flight commanders to command and lead the squadron, and must ensure, not only that they are fitted to carry out their duties, but also that they have subordinates in their flights trained to replace them when necessary.

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8. The flight commander is responsible for the training of his flight so as to fit it for battle. The basis of his training must be mutual confidence between the flight commander and his subordinates, which is produced by an intimate knowledge of each other's fighting and flying qualities. The flight commander should aim at developing, not only the skill of each of his subordinates as a fighting pilot, but the cohesion of his flight as a fighting unit.

9. The training of the fighting pilot should be progressive and consist of training both in the air and on the ground; it is divided into :—

(i) Individual training.
(ii) Collective training.

10. The object of individual training is to fit the pilot for war; it should aim at developing dash, self-confidence and initiative, as well as skill combined with the complete command of aeroplane and armament.

11. The object of collective training is to render the flight, squadron, or wing, and the larger units and formations, capable of manœuvre and co-operation in battle.

Individual training

12. It must be borne in mind that success in war is gained largely by moral qualities which may be fostered by training and example. Training should aim, not only to teach pupils how to fight, but to imbue them with the conviction of their own superiority as fighting pilots.

13. The training should consist of :—

(i) *Ground Training.*—A considerable part of fighting training is carried out on the ground; this ground training, whilst forming a necessary preliminary to fighting training in the air, will continue in its successive stages concurrently with training in the air. Training on the ground should include the following subjects :—

(*a*) Care, maintenance, and mechanism of machine guns and other armament.
(*b*) Rectification of machine gun stoppages and recognition of faults.
(*c*) Accurate aiming and use of sights (to be practised with model aircraft).
(*d*) Testing and care of ammunition.
(*e*) Aiming practice with camera guns at aeroplanes flying overhead.
(*f*) Firing practice at fixed and moving targets.
(*g*) Recognition of British and foreign aircraft.
(*h*) Theory of the tactics of air fighting.

(ii) *Flying.*—Before a pilot can hope to achieve success in air combat, he must be possessed of absolute confidence in his aeroplane, and must have acquired the art of handling her under all conditions. This skill in flying can only be

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retained by constant practice, which should aim at developing agility and accuracy, more especially in the following manœuvres: diving, side-slipping, flat turns, looping, climbing turns and half rolls. It is of particular importance that manœuvres, such as climbing turns, half rolls, steep turns, &c., should be practised to both sides; instructors should, therefore, insist on the same standard of efficiency for each manœuvre carried out to the left or right.

(iii) *The tactical application of aerobatics.*—Skill in the use of the various evolutions of flying, and the methods in which they should be applied in order to out-manœuvre the enemy.

(iv) *Judging distance, accuracy of aim, and skill in the use of machine guns and other air weapons.*—A pupil will require a considerable amount of practice in developing his judgment of distance in the air, the object aimed at being to manœuvre into a position as close to the enemy as possible without running the risk of collision. It cannot be too strongly impressed on all pilots and observers that the utmost skill in flying is of no avail unless complete efficiency in the use of the various sights and familiarity with the weapons used have been attained.

(v) *Air tactics.*

(vi) *Observation and recognition of aircraft.*—The ability to see and identify aircraft at a distance is vital in war, and must be developed by constant practice. Every effort must be made to train pilots to use their eyes and to develop a sense of intuitive vigilance. A definite system for keeping the sky under observation is necessary, in order that the pilot may avoid the danger of being attacked by surprise and that he may reap the benefit of seeing the enemy before being seen. Instruction in recognition of aircraft may first be given by using silhouettes which the pupil is made to identify from a distance of 15 to 20 yards. These silhouettes must include one of each type of aircraft illustrating its appearance as seen when it is approaching the onlooker head-on. Later, the pupil should be shown how to divide the sky into three sectors, when flying, by means of the top plane and centre-section struts, and examine each sector separately. First the pilot should search the air above and below his tail, examining any blind spots by swinging his tail from side to side, then the sector from port wing-tip to centre section should be searched, then the sector from centre section to starboard wing-tip. The upper sky must then be examined by taking a steady sweep upwards from starboard wing-tip to port wing-tip, each position of the sky being scrutinised minutely; otherwise a hostile aeroplane approaching end-on may easily escape notice. If this examination is carried out systematically and constantly, the whole sky will be kept under observation.

14. Fighting-training in the air should consist alternately of dual-control instruction and solo practices, each lesson being

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explained and demonstrated by the instructor before being put into execution by the pupil. Air training is sub-divided into :—

(i) Elementary training.

(ii) Advanced training.

15. In elementary training the pilot is taught :—

(i) To place his aeroplane in any possible position, and have complete and instinctive control at all times.

(ii) To aim accurately and steadily whilst flying and diving.

(iii) To manœuvre so as to align his guns on air or ground targets in the shortest possible time.

(iv) To dive correctly and to turn quickly from any position into a dive.

(v) To aim correctly at moving targets on the ground or in the air.

(vi) To rectify machine-gun stoppages in the air.

16. Advanced training should include the following lessons :—

(i) How to approach various classes of aircraft.—In order to train pilots in the art of approaching an enemy, certain aeroplanes, preferably flown by experienced pilots, should be detailed to represent hostile aircraft. The instructor should then take up a certain number of pupils, flying in formation, and order each one in turn to approach and attack an opponent while the remainder of the formation watch from a distance and make critical notes. By this method, a pupil is taught the various stratagems employed in concealing an approach, and benefits by the criticisms of his instructor and fellow pupils.

(ii) How to take advantage of background to conceal the approach.

(iii) How to make use of the sun to screen the approach or retreat.

(iv) How to make use of clouds and mist in order to effect a surprise attack.

(v) How to take advantage of an opponent's blind spots.

(vi) How to co-operate with the back-gunner in a two-seater.

17. In advanced training, the pilot should be armed with a camera gun and taught how to fight another pilot. The pupil should first be taken up by the instructor with dual control. The latter then explains each manœuvre clearly through the telephone, and demonstrates the correct method of approaching and attacking an opponent. During the next stage, the pupil takes charge and carries out an attack, whilst the instructor criticises. Great care should be taken to explain the tactics adopted by the opponent, and to point out the correct method of manœuvring.

18. When lecturing to pilots on air fighting, use should be made of photographs, cinematograph films, and model aeroplanes, in order to illustrate the following points :—

(i) *The vital spots of an aircraft.*—These generally consist of pilot, engine and petrol tanks.

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The instructor should demonstrate how fire may be directed against an aeroplane in such a way as to bring the greatest number of vital spots into the zone of fire.

(ii) *The blind spots of the pilot.*—The instructor should explain and demonstrate how to approach an aeroplane so as to make use of the opponent's blind spots and point out how these vary with each type.

(iii) The blind spots of the observer, in a two-seater aeroplane.

(iv) Methods of keeping the sky under observation for the presence of other aircraft.

19. While receiving preliminary training in the application of aerobatics to fighting, pilots should be warned against the following faults :—

(i) Excessive speed, which reduces the power of manœuvre.

(ii) Too sudden a change of direction.

(iii) Changing altitude too suddenly, which affects the physical condition of the pilot.

(iv) Losing height unnecessarily whilst manœuvring.

20. When pupils can attack creditably, two of them should be sent up to fight one another, the instructor watching the combat either from the ground or from the air. Careful criticism at this stage is all-important, and can conveniently be classified under three headings :—

(i) Tactics.
(ii) Aim.
(iii) Range.

Tactics can only be criticised from the personal observation of the instructor, but aim and range are shown by the camera gun photographs. If at any time the pupil has difficulty in performing a particular manœuvre, he should be taken up in a dual-control aeroplane and shown how to carry it out.

21. As a final practice, the pupil should be taught how to study his opponent and estimate his weakest points. He should be able to make use of blind spots, and, when attacking two-seater or multi-seater aircraft, be capable of deciding quickly from which direction an attack is likely to succeed.

Air Gunnery

22. *The importance of accurate marksmanship cannot be overestimated, since it is necessary to hit an aircraft in a vital spot in order to destroy it. Pupils, both pilots and air gunners, should be encouraged to spend as much time as possible in handling and firing their guns in order that they may learn to use them to the best advantage under all circumstances.*

23. The theory and practice of air gunnery are laid down in the Armament Training Manual (Parts I and III) and the pupil will undergo a thorough course of training in these subjects during his preliminary ground instruction. Training in the

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tactical application of gunnery should be carried out concurrently with other fighting training.

24. The manipulation of machine-guns in the air and the rectification of stoppages and other faults which may occur while firing are far more difficult to perform accurately and speedily in the air than on the ground; it is, therefore, essential that pilots and observers should have an intimate knowledge of the machine-gun, and be able to rectify stoppages whenever they occur whilst flying.

25. On the ground, a pupil should be taught to aim and to maintain his aim when firing from a moving fuselage at fixed and moving targets. In the air, a pupil should be taught to combine his knowledge of flying with his knowledge of the machine-gun; and this training should include the following:—

(i) Grouping practices at fixed targets; *i.e.*, how to dive and fire bursts at a target on the ground.

(ii) Grouping practices at moving targets both on the ground and in the air.

(iii) Deflection practice which can best be taught by the use of camera guns, since the film will show an exact record of the pilot's aim at the moment of pressing the trigger.

26. The instructor should explain that in the air a pilot's aim is constantly thrown off, and that it will, therefore, be necessary to relay the aim frequently; this implies that short bursts only should be fired, the aim being relaid at the commencement of each burst.

27. Before a pilot is permitted to fire his gun from the air, he should first be made to carry out the various practices with a camera gun. By this test, a pupil's progress can be checked and his faults discovered. The camera gun films should show whether:—

(i) A satisfactory angle of dive has been attained.

(ii) The trigger has been pressed at the correct range.

28. A pilot should be trained to accustom himself to different angles and speeds of approach, so that when he attacks he is capable of estimating the deflection correctly.

29. The pilot who is destined to fly a two-seater aeroplane should be taught how to co-operate with a gunner. After he has mastered the use of his front gun in attack, he should be taken up to act as gunner to the instructor; the latter should then attack another aircraft, and, during the ensuing practice-combat, manœuvre so as to allow the pupil to use his camera gun. During the combat, the instructor should explain through the telephone how he manœuvres to afford the gunner a good view of the enemy. He should explain how, instead of trying continually to turn towards the hostile aeroplane and use his front gun, he manœuvres so as to allow the gunner to use his weapons effectively. When the pupil has thus experienced the gunner's "point of view," he should be sent up

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to pilot a two-seater aeroplane carrying a skilled gunner who will instruct him in co-operation, and check him if he does not afford the correct openings for the back gun.

30. At the end of this stage in his fighting training, the pupil should be expert in using his gun in the air, in aiming at and attacking another aircraft, and in defending himself to the best advantage.

Collective training

31. When pilots have attained proficiency in individual fighting and have acquired the principles of air drill (which they should be taught concurrently with their individual training in air fighting), they should commence collective training.

32. In collective training the pupil is taught to apply the lessons learnt in individual training, and to co-operate with the rest of his unit under the direction of a leader.

33. Collective training should consist of :—

(i) Air drill (*see* Chapter II and the Provisional Manual of Air Drill).
(ii) Instruction in the tactics of fighting in formation.
(iii) Air manœuvres.
(iv) Combined manœuvres, *i.e.*, manœuvres carried out in conjunction with the other services.

34. The most instructive method of carrying out collective battle training is by a series of schemes in which the air forces taking part are divided into "red" and "blue" forces, a definite line being chosen on the ground which divides the territory occupied by "red" and "blue" troops.

35. If each pilot and, for two-seater aeroplanes, each observer can be provided with a camera gun, a valuable test of the skill displayed by individuals during the fight can be obtained. At the end of the day the films of all camera guns should be collected, and an approximate idea of the results of the day's fighting can then be arrived at. They should be imparted to pupils in a lecture at which any tactical errors made are pointed out.

36. It is essential that aircraft detailed to opposing sides should be of a definite type or types, which should be clearly stated when orders for the schemes are being issued: by this means pilots will be able to exercise their powers of observation in the air. Practice in the recognition of aircraft may be given by handing each pilot a paper, ruled in columns, headed with the designation of various types of aircraft likely to be encountered, one column being left for those of unknown type. During the flight, at a pre-arranged time, or on a given signal, each pilot should mark down the number of aircraft of each type which he can see. The instructor should make a similar note and compare his list with those of the other pilots.

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37. During collective training every effort should be made to foster *esprit de corps*, and the pilot who has been taught to fight as an individual will now have to learn to take his place as the member of a unit and to realise that the flight, or squadron, is of more importance than the individuals which compose it.

Training of the leader

38. The characteristics of air warfare entail the necessity for quick decision and prompt action on the part of subordinate commanders, and it is, therefore, of the utmost importance that initiative and resolution of purpose be developed during training.

39. The leader of a formation incurs a heavy responsibility, since it is he who determines the course to be steered, decides when to attack and when to withdraw, and orders the tactical disposition of his command; he should, therefore, have sound air experience, which can only be gained in peace by constant practice, and by thinking out and deciding how best to meet definite tactical problems with which he is likely to be confronted in war. He needs imagination in order to have the power of anticipating future developments in air warfare, and organising ability in order to devise methods to meet them.

Training of night fighting pilots

40. Night fighting requires special training both in flying and in the use of weapons by night. The tactics employed in night fighting are described in paras. 170–189 of this Chapter.

41. As soon as a pilot has acquired sufficient skill in flying by night to enable him to find his way and land without difficulty, he should be instructed in approaching another aeroplane and manœuvring to secure a fighting position. This should first be taught by daylight, and practised until the pilot is capable of attaining the best position, *i.e.*, slightly astern and below the tail of the opponent. During these preliminary practices the pupil should carry a camera gun, and demonstrate his ability to align his sights and fire an effective burst at decisive range.

42. Practice in approach and attack should then be carried out by moonlight, two pilots being detailed to ascend and rendezvous at 2,000 feet over a corner of the aerodrome, with navigation lights burning. The pilot designated for the rôle of the attacker will leave his lights burning, and will take up his position. The second pilot will extinguish his lights and fly along on a level course, watching his opponent and making a note of any mistakes committed.

43. Gunnery should be practised at night, both in the air and on the ground, care being taken to use the same sight on the ground as in the air. It is desirable that a pilot should receive practice in clearing jambs in the dark, and that he should accustom himself to handling his gun and manipulating its mechanism entirely by touch.

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INDIVIDUAL ATTACK

General principles

44. Although a decisive victory over the enemy's air forces can only be gained by the concerted action of a considerable number of aircraft controlled by a leader, independent fighting will often be necessary by individual pilots, sent up either to attack and destroy any small hostile formations or unsupported aircraft they may encounter, or to carry out some special mission; moreover, owing to the fact that an engagement between two air formations will sometimes resolve into a series of duels between individuals, the general principles of individual fighting will sometimes apply to collective fighting, when the battle has developed. Individual attack facilitates surprise, which will often enable a solitary pilot possessing initiative and boldness to achieve success against superior numbers. On the other hand, a pilot acting alone, especially when flying a single-seater aeroplane, will himself be liable to surprise attack, so that only the most experienced and able pilots should be selected for individual missions.

45. Certain definite principles of air fighting are common to all types of aeroplanes : these are :—

(i) To discover the enemy first.

(ii) Altitude confers tactical advantage.

(iii) The will to conquer, determination and coolness are essential to success.

(iv) If surprised or forced into an unfavourable position, a pilot must never, in any circumstances, dive straight away from his opponent.

(v) Fire should be opened as close to the enemy as possible.

(vi) Accuracy of aim and careful shooting are essential.

(vii) Every aircraft should be treated as hostile until its identity is established beyond shadow of doubt.

46. After an engagement, pilots should discuss its various phases among themselves; they will thus be able to realise what mistakes, if any, have been committed, and what alternative tactics should have been employed.

47. The direction and strength of the wind should be noted before leaving the ground, as this will assist the pilot in locating his position after a combat. Air pilotage should be cultivated, and is of special importance later when the pilot has to lead his patrol. During a fight a pilot's whole attention is concentrated on the defeat of his opponent, and he has little time to study his map or note the country over which he is passing. At the conclusion of a battle he may thus find himself at a considerable distance from the district over which he was flying when he first engaged the enemy, and must be able to locate himself rapidly and accurately. This ability to find his way without loss of time is essential to a fighting pilot, since it may often make the

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difference between getting back to his aerodrome or being compelled to land in enemy territory owing to lack of petrol.

48. Air gunnery is complicated by the fact that both gun and target are moving at variable speeds and on variable courses, consequently the period during which a pilot can align his sights on an opponent is necessarily of very short duration; it is therefore of the utmost importance that no opportunity should be lost in battle.

49. The range at which fire should be opened will vary according to circumstances, the guiding principle being that the longer fire can be reserved and the shorter the range, the greater the probability of a decisive result. Pilots and gunners must accustom themselves to judge the range by the apparent size of the hostile aeroplane and the clearness with which its details can be seen.

50. A pilot should endeavour to retain vivid and detailed impressions of every fight in which he takes part. Besides the necessity of recording the details and results of air engagements, a pilot will learn more about air tactics and about the habits of the enemy by careful analysis of his own experiences than by any amount of training.

The approach

51. A pilot's ability to carry out a successful attack is dependent to a large extent on his powers of observation and on the facility with which he can discern and identify hostile aircraft at a distance. In approaching an enemy, the primary object should be to arrive within effective range without being observed. This will confer upon the attacker the supreme advantage of surprise.

52. A surprise attack creates a great moral effect upon an adversary; as a result, a hostile pilot, when taken by surprise, may momentarily lose his presence of mind, and either dive or place his aeroplane in such a position as to form a vulnerable target for the attacker.

53. Surprise may be achieved in the following ways:—

(i) By approach from the direction of the sun. When the sun is shining brightly it is extremely difficult to see an aeroplane approaching from its direction owing to the blinding effect of the sun's rays. The reverse is the case, however, when the sun's rays are diffused as the attacker shows up very plainly. He should, therefore, approach from the opposite direction.

(ii) By approaching from the edge of the bank of mist or haze which in summer appears to cloak the horizon.

(iii) By approaching from behind or above the clouds and seizing a favourable opportunity to dive out of the clouds on to the unsuspecting opponent. In cloudy weather the approach may often be concealed by utilising as cover the small, white clouds which are to be found at a high altitude.

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(iv) By making use of the enemy's blind spots. An intimate knowledge of the enemy's aircraft is required in order that full advantage may be taken of its vulnerable points. Pilots should study their opponents' aircraft and acquaint themselves with their characteristics, so that they may decide upon the best method of attack.

54. Careful observation of an enemy's movements and the type of aircraft which he is flying will often reveal the duty upon which he is engaged, and thus afford the attacker information upon which he may base his attack; thus, if the attacker discovers a hostile two-seater engaged upon artillery observation, he may, on occasion, by waiting concealed behind a cloud, seize a favourable opportunity to destroy him; whereas, if the enemy is observed to be flying on a long reconnaissance or on some special mission, an immediate attack is more likely to achieve success.

55. Even when in view, surprise is possible to a pilot who is thoroughly at home in the air, and can place his aeroplane, by a sudden evolution, in an unexpected position on the enemy's blind side, or under his tail.

56. Aeroplanes at a distance often disclose their presence by the flashing of sunlight from the planes or struts; it is, therefore, important that when approaching an enemy no steep banking be attempted.

57. Hostile aircraft which are patrolling at a considerable altitude may sometimes be taken by surprise if the attacker approaches by flying low and then climbs to attack them from the direction of their own aerodrome; but this method of approach suffers from the great disadvantage that it allows the enemy the tactical advantage of superior altitude.

58. A successful surprise attack enables a pilot to open fire at decisive range before his enemy is aware of his presence; it should therefore be the aim of the attacker to get as close to the hostile aircraft as possible, and not to open fire until he is quite certain of hitting the mark with his first burst of fire, unless the enemy shows by diving or turning that the attack has been discovered.

Methods of attack

59. Altitude confers a tactical advantage upon the attacker, because, being above his opponent, he always has a reserve of speed to carry him back into position after a dive. Moreover, being above, he can afford to lose height in a turn, and can therefore more easily out-manœuvre his opponent. Although, as a rule, altitude should be retained by the use of climbing turns, it may sometimes be advisable to go below an opponent after an unsuccessful attack, since many types of aircraft have an excellent view above, but, owing to planes and engine, are " blind " below. If, after an unsuccessful dive, the attacker " carries on " below the enemy, the latter will lose sight of him momentarily, and the attacker can seize this opportunity to formulate a fresh plan of attack and regain position.

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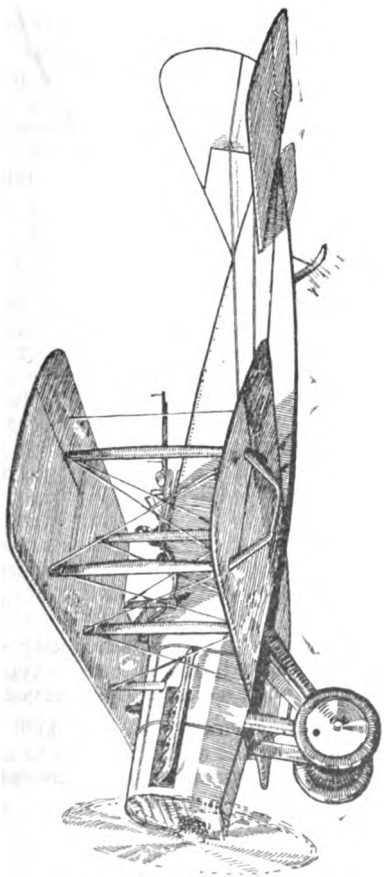

FIG. 14.—APPROACHING A TWO-SEATER.

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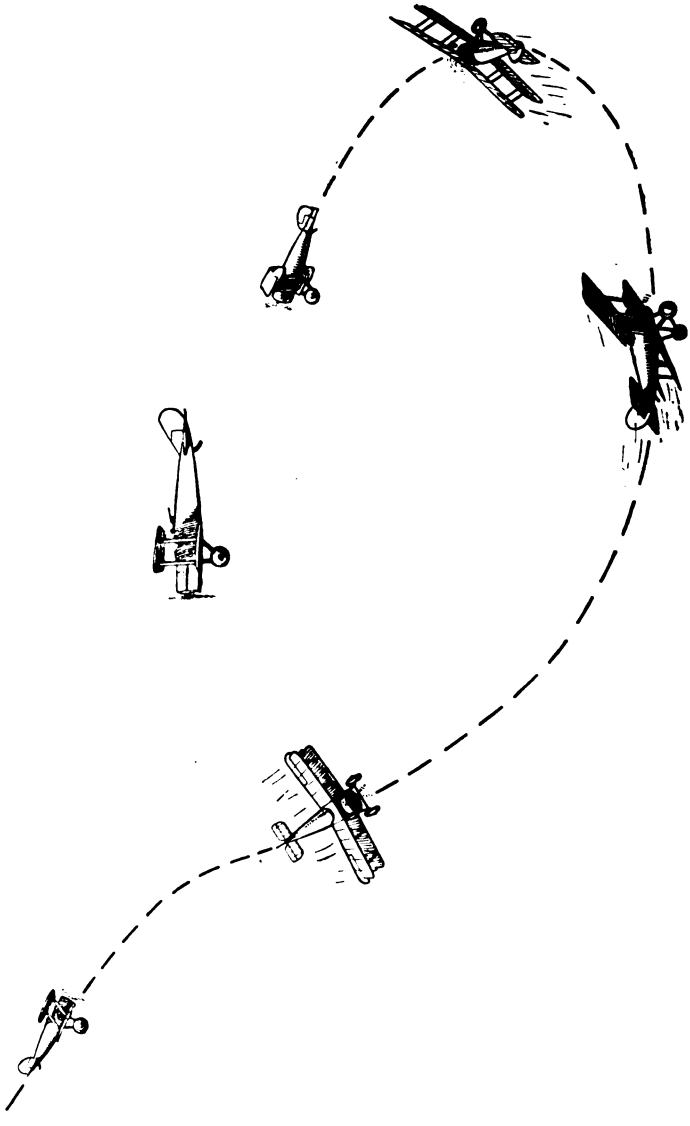

FIG. 15.—METHOD OF ATTACKING A TWO-SEATER.

60. Although it is not possible to lay down definitely what methods of approach should be adopted against various types of aircraft, the following guiding principles should be observed :—

(i) Single-seaters should, generally, be attacked from above and astern, the object of the attacker being to arrive at decisive range before his opponent is aware of his

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approach. In diving to attack, it is essential to have plenty of engine-power in hand, since the fact that the attacker has a reserve of speed in hand will enable him to anticipate his opponent's next move. With a view to obtaining this advantage, a close watch should be kept on the rudder of the opponent, as it will often afford an indication of the direction in which the hostile pilot intends to turn, before his aeroplane actually responds to the movement of the controls.

(ii) Two-seater aeroplanes should, as a rule, be attacked from below or from any blind angle, the most unfavourable position for the attack being astern and slightly above, in which position the attacker is fully exposed to the back gunner's fire. A skilfully-handled single-seater which can attain a position about 100 yards behind and 50 feet below a hostile two-seater, without being observed, is in a position to do most damage to the enemy with least risk to himself. Once in this position, the object of the attacker must be to keep out of the enemy's field of fire and to get to close quarters. The two-seater will endeavour to bring fire to bear on the attacker by turning quickly in order to deprive him of the cover of the fuselage, and great skill is required to retain a position directly in rear.

61. When attacking each other "end on," both pilots are exposed to similar conditions. This method of approaching an enemy should not therefore be resorted to. If the hostile aeroplane has a large engine in front, the attack, even if successful, will in all probability merely damage the engine and not kill the pilot.

62. A method of attack which may be employed with success against a hostile aeroplane with a broad fuselage and large engine, is to fly straight at the opponent, "end on," until within range of about 500 yards. The attacker should then dive steeply as if to pass under the enemy, firing a burst from his gun to draw the observer's fire to the front, but instead he should execute a quick turn whilst concealed from view by the hostile aeroplane's engine and fuselage; this turn should bring him into a position from which he is afforded an easy shot from astern and below, with the additional advantage that the enemy pilot is no longer protected by his engine. This position of the attacker, under the enemy and flying in the same direction, will give him the opportunity of firing a long burst before the attack can be countered. If the enemy turns, the attacker will be in a position to execute a quick turn and resume the attack. When approaching "end on," it should be borne in mind that the opponents are drawing nearer to each other at great speed, and the time available for manœuvre will therefore be far less.

63. When diving to attack, the greater the speed of the dive, the more fleeting will be the opportunity for firing: it is therefore of importance that the dive should be commenced with as little speed as possible.

64. Unless the pilot has acquired complete familiarity with his engine and is thoroughly acquainted with the use of his

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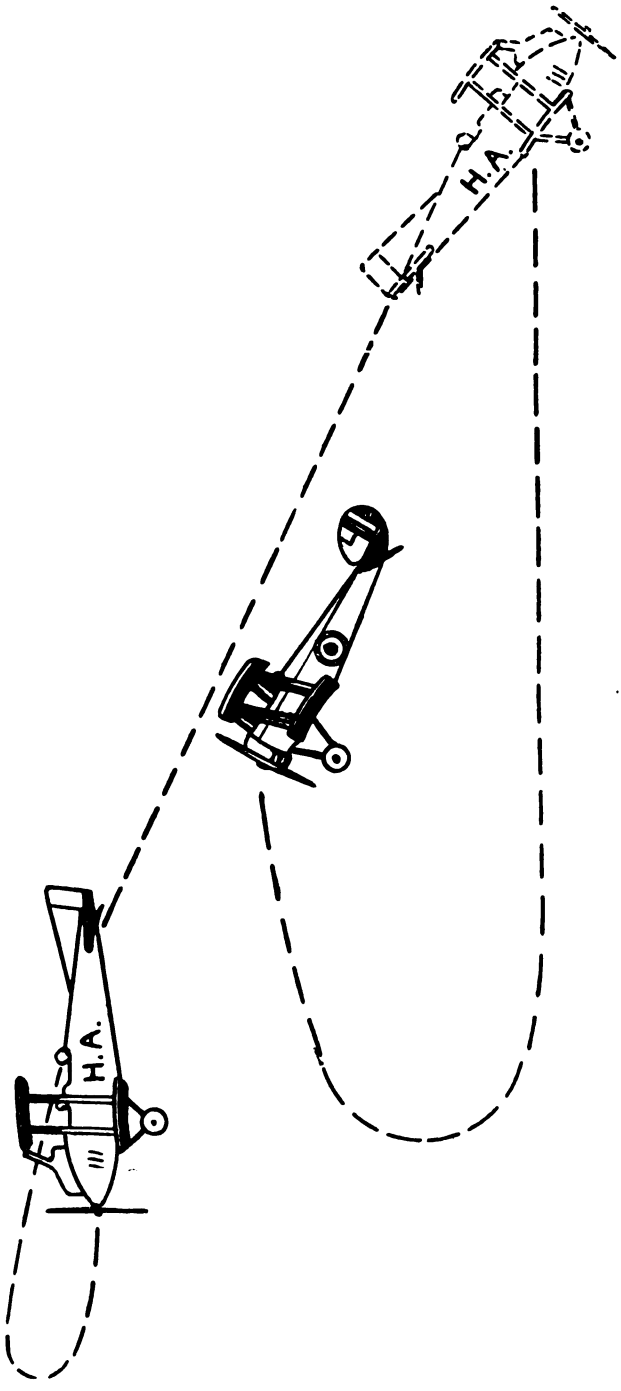

FIG. 16.—ATTACK OF TWO-SEATER FROM BELOW, SHOWING TURN.

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throttle, he will in all probability experience engine trouble at the critical moment in a fight when speed and climb may be the deciding factor between victory and defeat.

65. Attacks delivered from a flank are often successful, since the vital parts of the aeroplane and the pilot are fully exposed. A flank attack necessitates accurate deflection shooting; the aim being directed in front of the nose of the hostile aeroplane (*see* Fig. 19). In the same way, when an attack is delivered from above and astern, aim should be directed in front of the leading edge of the top plane in order to hit pilot or engine.

66. An intimate relationship should exist between anti-aircraft batteries and fighting pilots, a code of signals should be arranged, so as to enable ground observers to notify pilots engaged in offensive patrol duties of the whereabouts of hostile aircraft.

67. A surprise attack may often be successfully achieved on a cloudy day, because the weather will encourage the enemy to send out aeroplanes on long-distance reconnaissance in the hope that they may escape notice. Cloudy weather, once the enemy has been observed, favours the attacker, who should endeavour to keep out of sight until the very last moment. It should be borne in mind that in such weather it is often of advantage to approach the hostile aeroplane on its own level, when the planes form but a thin line which it is difficult to see.

Characteristics of the single-seater in attack

68. Single-seater fighting calls for much initiative, skill and rapidity of thought. Success will generally be achieved by the pilot who, in addition to the qualities required by a fighting pilot, possesses the ability of adapting himself immediately to varying situations, and is capable of studying his opponent and formulating a tactical plan which on its execution will bring the attacker into position to fire on the target before the enemy can counter the attack.

69. Although as a general rule single-seaters do not act alone, yet sometimes, when a formation has become disorganised as the result of an engagement, isolated pilots will be called upon to fight individually. Again, selected pilots on the fastest types of single-seaters may be usefully employed on roving commissions, which will enable them to make the greatest use of surprise tactics. As he has no armament firing astern, the single-seater pilot will have to exercise the utmost vigilance to avoid being surprised, and this will be all the more necessary when he is himself intent upon stalking an apparently unsuspecting enemy.

70. An attack should be delivered with caution, but once attempted should be driven home with resolute determination to destroy the enemy. Pilots who have achieved a number of successes are apt to become over-confident, and should be warned against the dangers of carelessness.

71. When it is necessary to swerve to avoid a collision or to break off the combat temporarily in order to change a drum or rectify a jamb, it should be carried out by executing a sudden

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climbing turn, applying too much rudder, which will cause the aeroplane to slip upwards and outwards. When ready to renew the fight, the attacker should regain a favourable position by manœuvre.

Characteristics of the two-seater in attack

72. Although the general principles of air warfare apply equally to fighting in a two-seater aeroplane, success will depend primarily on the intimate co-operation of pilot and gunner. This close co-operation can only be achieved after considerable practice, and is based on the mutual confidence between pilot and gunner and in the ability to inter-communicate by signs or by some other method, so that each occupant of the aeroplane is always acquainted with the intentions of his companion. It is therefore desirable that the same pilot and gunner should, whenever possible, work together, both in the air and on the ground, in order that mutual knowledge of the methods adopted by each may be developed; and also that the pilot may gain absolute confidence in the vigilance and marksmanship of the gunner, and the gunner in the skill and tactical knowledge of the pilot.

73. In air fighting, the pilot of a two-seater aeroplane is forced to rely just as much on his power of developing fire in all directions as on his quickness of manœuvre; thus, although his tactics in attack are similar to those of the single-seater pilot, he possesses the ability to bring fire to bear against his adversary after passing him, or on the turn. The actual tactics to be employed in two-seater fighting are dependent on the particular type of aeroplane flown and on the requirements of the moment. For offensive purposes, the forward guns are to be regarded as the principal weapons, but are supplemented, whenever possible, or when the pilot is not in a position to attack, by the armament of the gunner.

74. The pilot of a two-seater should receive instruction in the duties of a gunner, so that he may be familiar with the latter's point of view and with the effectiveness of his fire in different situations. In battle he should resist the temptation to regain position for an attack with his forward guns immediately he passes his opponent, but should know and carry out the manœuvre which will afford to the gunner the best opportunity for the employment of his armament.

75. The air gunner should be absolutely at home in the air, efficient to a high degree in the use of his weapons, skilled in co-operating with his pilot and in identifying aircraft from a distance, and, above all, vigilant. The gunner should economise his ammunition, and, when fighting at a distance from his aerodrome, should retain a reserve for the return journey.

Attack of two-seater and multi-seater aeroplanes

76. The attack of a two-seater aeroplane requires forethought; since, owing to its power of developing fire astern, it cannot, as

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a rule, be approached with impunity like a single-seater. Success will be achieved by the pilot who acquires an intimate knowledge of the "blind angles," of the powers of manœuvre, of armament and other characteristics of his opponent.

77. When a hostile two-seater aeroplane is observed, its movements should be studied in order that the duty upon which it is engaged may be discovered, as this will influence the method of approach. For instance, if from his movements or from ground indications, the hostile pilot appears to be engaged in artillery observation, it may be advisable to delay the attack until both pilot and gunner of the hostile aeroplane gain confidence and relax their vigilance; the enemy may then be approached from the direction of his own territory and surprised when he is least suspecting an attack. On the other hand, hostile reconnaissance or bombing aircraft may have to be attacked immediately, or they will escape.

78. The primary object of the attacker will be to surprise his enemy and arrive within decisive range before the hostile gunner is aware of his presence. This may be more readily achieved by approaching from below, in which position the attacker is partly shielded from view by the fuselage and planes of the hostile aeroplane. If the approach is successful, the attacker should endeavour to keep immediately under the enemy's fuselage and slightly astern, from which position he can open fire at decisive range. If the hostile pilot should alter course while the attacker is in this position, the latter should turn in the opposite direction and resume the attack as soon as the enemy has taken up a new course.

79. An approach from above is more likely to be successful if the attacker executes a very steep dive immediately ahead of the enemy, and endeavours to shield himself from view with the upper planes of the hostile aeroplane. Even if he is discovered whilst diving in this position, the accuracy of the hostile gunner will be impaired by his having to fire vertically upwards.

80. When diving at an enemy from ahead, the attacker, as soon as he arrives within suitable range, should execute a turn which will bring him into position on the enemy's tail, care being taken not to turn too late; otherwise, on completion of the turn, the attacker will find himself some distance astern of the enemy, and will be forced to approach to decisive range in full view of the hostile gunner (*see* Fig. 17).

81. The discovery of his approach will be apparent to the attacker, who should thereupon endeavour, by some rapid manœuvre, to place himself in firing position and deliver the attack from an unexpected quarter.

82. The first result of diving at a hostile aeroplane may frequently be to cause the enemy pilot to dive steeply, since this impulse is instinctive in most pilots when taken by surprise.

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If this should occur, the attack may be driven home with impunity, as the hostile gunner will be unable to use his gun effectively as long as he is in this position; moreover, the hostile aeroplane will afford an excellent target.

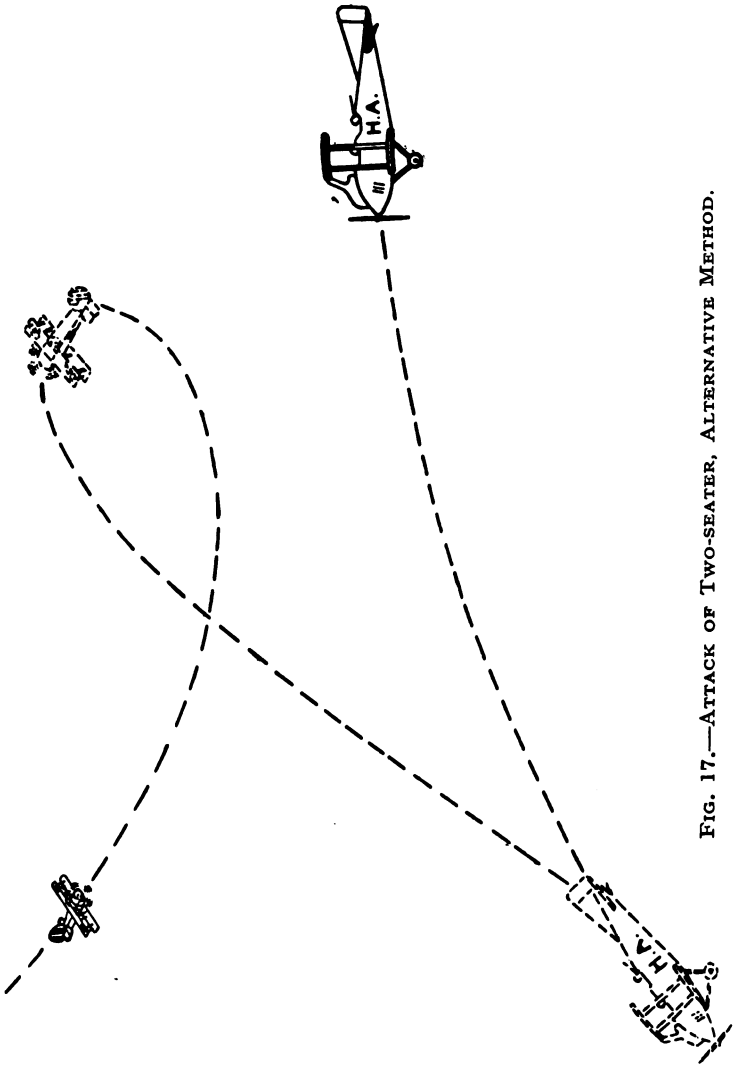

FIG. 17.—ATTACK OF TWO-SEATER, ALTERNATIVE METHOD.

83. Another method of attack from astern is to dive steeply when still out of effective range, and then, when the hostile gunner is expecting the attack from above, to use the extra speed gained

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during the dive to come up under the enemy's tail (*see* Fig. 18). The object of the attacking pilot, once he has been discovered by the enemy, should be to confuse both pilot and gunner of the hostile aircraft. He can do this by executing unexpected manœuvres and by constantly varying his method of attack. If the attack be delivered from under the tail, the fuselage and tail plane of the enemy may be used as cover from the fire of his stern guns. The gunner will endeavour to prevent this by firing over the side of the cockpit, but his aim may be disturbed by altering position from one side of the fuselage to the other.

84. A hostile aeroplane provided with a gun tunnel through the floor of the fuselage should not be attacked from directly under the tail, but may be approached at an angle.

85. A combined attack against a two-seater by two or more pilots will greatly facilitate success; for, while one pilot occupies the attention of the hostile gunner, the other may deliver a sudden attack from an unexpected quarter. This may be carried out in the following manner:—Pilot No. 1 signals his intention of attacking, and attracts the hostile gunner's attention by executing short dives, at the same time firing his guns. In order not to expose himself unduly, and so as to confuse the hostile gunner, his dives should be irregular. Meanwhile pilot No. 2 makes a *detour* and endeavours to obtain a favourable position under the tail of the enemy from which he can deliver a decisive attack at short range (*see* Fig. 20).

86. When a pilot in a single-seater aeroplane attacks a two-seater, the former generally has the advantage in speed; if this is so, when the enemy alters course the attacker should turn in the opposite direction to avoid over-shooting, and should resume the attack as opportunity occurs.

87. When on a bank in the act of turning, the two-seater will offer a favourable target, if the attacker is quick enough to take advantage of it. A short quick burst at this moment may confuse the pilot and cause him to dive steeply, in which position it will be extremely difficult for the hostile gunner to fire.

88. Aircraft when severely damaged by machine-gun fire sometimes fall to pieces in the air; this point should be borne in mind when closing in on an enemy, especially during a steep dive, in order that the wreckage may be avoided by executing a quick turn or side slip.

89. In the attack on multi-seater aircraft the same principles apply, though, owing to their added powers of developing fire, surprise is even more essential to success.

COLLECTIVE ATTACK

General principles

90. With large calibre guns and improvement in sights and protective armour, collective fighting at long ranges may become

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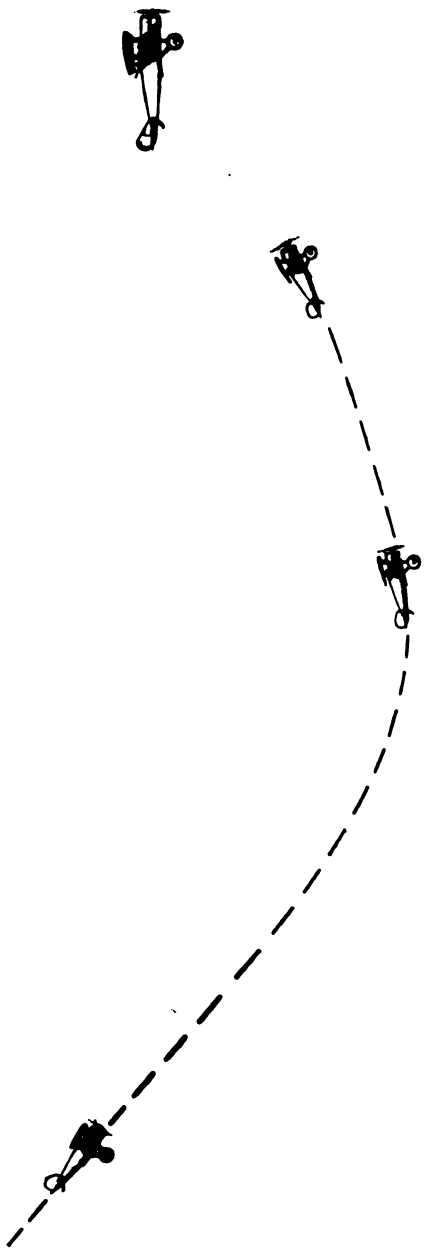

FIG. 18.—ATTACK OF TWO-SEATER FROM ASTERN.

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necessary; but victory at present can only be attained by driving home the attack at close quarters. With this object in view, the opening of fire in the attack should not be permitted, except by order of the formation leader, whose object will be to develop the greatest volume of fire at decisive range against the enemy's most vulnerable point.

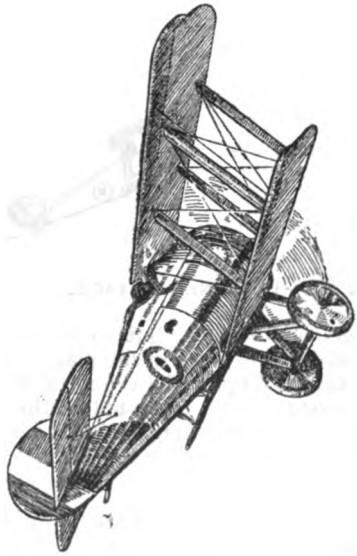

FIG. 19.—ATTACK FROM A FLANK.

91. Discipline is necessary at all times, but especially so when aircraft are attacking in formation. A pilot may be perfect in formation flying and may have distinguished himself in individual

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fighting, but if he forgets his orders or disregards the leader's signals when he observes an enemy, he will be unfitted to take part in collective fighting. The fighting pilot is required not

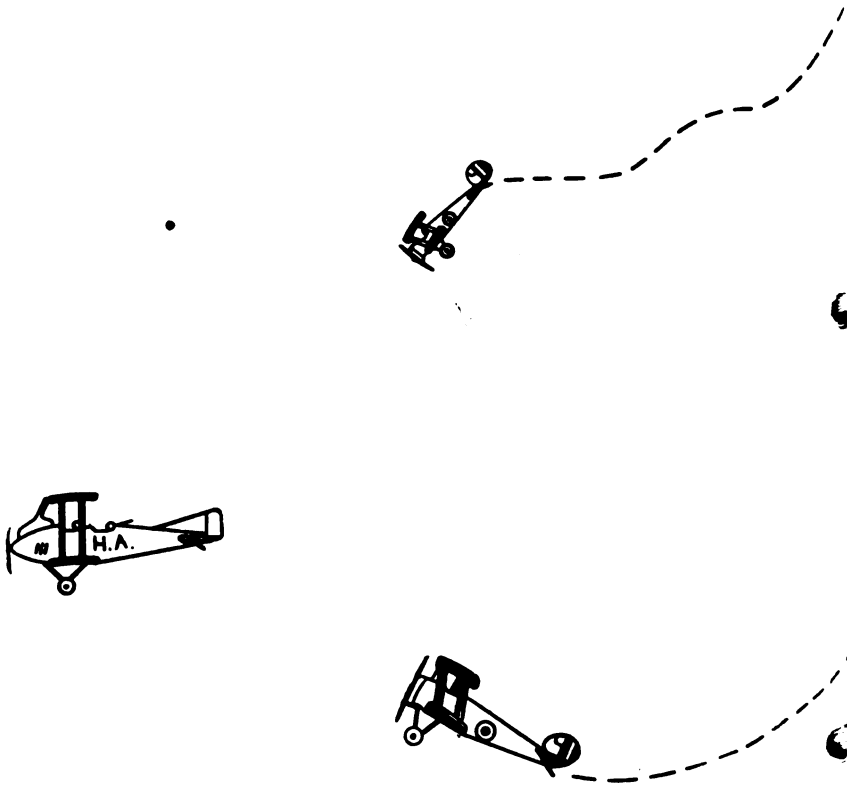

FIG. 20.—COMBINED ATTACK.

merely to obey orders and signals, but to subject himself to rigid discipline. He must always be in his place, and should be so familiar with the tactics employed by his leader that he can almost anticipate his commands. If he fail in this, he will not only lose the opportunity of destroying hostile aeroplanes that the leader points out to him, but he will interfere with the remainder of the attack.

92. An attack against a hostile formation can only be successful when it is controlled by a leader who can judge when and from what direction maximum fire effect shall be brought to bear, the primary object of the attack being to disorganise the enemy so that his aircraft may be destroyed individually.

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93. Once an attack has been launched, it must be pressed home with determination: only the destruction of the enemy, or a signal from the leader, should end the battle.

94. Successful approach will depend to a large extent on the skill of the leader, who must use his initiative and vary his methods

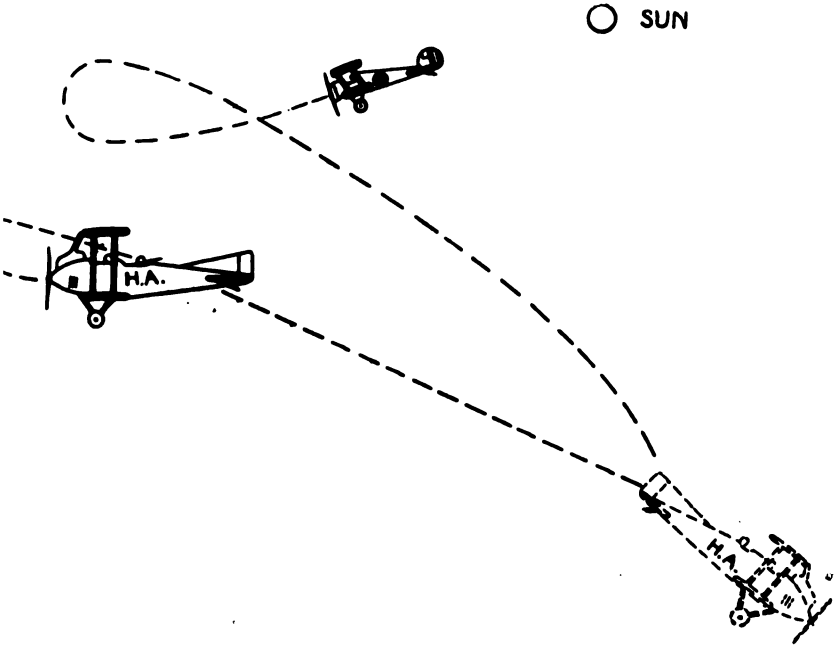

FIG. 21.—ATTACK OF TWO-SEATER FROM ABOVE, SHOWING TURN.

according to the situation. Surprise attack is more difficult for a formation than for an individual, but it should, nevertheless, be attempted according to the principles laid down in paras. 51–58.

95. If the hostile formation to be attacked is superior in numbers, the attack should be launched with the greatest determination and dash, which will tend to increase its effect on the enemy's *morale*. As soon as the leader of the attacking formation observes that the enemy are aware of his approach, he should formulate his tactical plan of attack. The sooner the attack is delivered and the more determination is shown in driving it home, the less time will be afforded to the hostile leader to organise his counter-measures.

96. When the attack is launched, it is of great importance that fire should be opened simultaneously by the whole formation, and that pilots flying in the flight sub-formations (*see* Chapter II., paras. 17–20) should keep together and should concentrate fire

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against the same objectives. If this is carried out effectively, the hostile formation will tend to become disorganised and can be destroyed in detail.

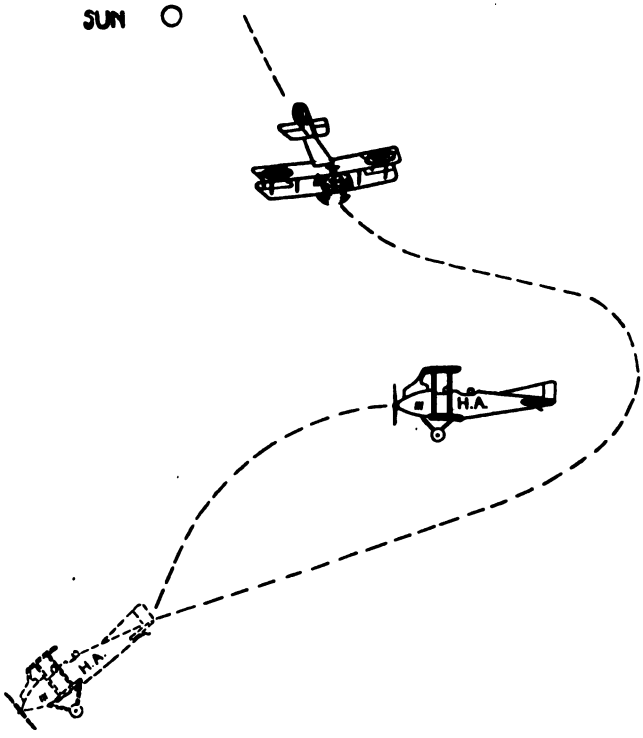

FIG. 22.—ALTERNATIVE ATTACK FROM A FLANK.

97. A pilot whose engine is running unsatisfactorily should drop out of the formation and return to his aerodrome, if possible before the formation starts on its mission. If he attempts to continue with a failing engine, not only does he run the risk of being cut off himself, but he may greatly hamper the leader when in face of the enemy. Any pilot who experiences engine failure while over enemy territory should make the necessary signal (*see* Chapter II, para. 27), and turn towards home, whereupon, subject to the leader's discretion, he will usually be escorted back to safety. A pilot with a failing engine should not attempt to keep at the same altitude as his escort at the expense of his speed, but should maintain course, flying vertically below his escort.

Sub-formations in attack

98. The basis of all formations is the flight sub-formation (*see* Chapter II, paras. 17–20), the pilots of which should always be

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trained to fly and fight together. As a general rule, pilots should not be employed to make up deficiencies in flights other than their own.

99. No definite regulations can be laid down for the employment of sub-formations during an air fight owing to the rapidity with which the tactical situation may change; but success will depend upon the efficiency of inter-communication between the leader of the formation and the sub-formation leaders, and on the ability of the former to make up his mind quickly and decisively.

100. Sub-formations will normally be echeloned in height, the highest sub-formation being usually in the nature of a reserve. The principle governing the employment of the reserve is that the enemy should be attacked with great vigour as soon as they appear to lose cohesion as the result of the attack. If the enemy is surprised, it is of the utmost importance to increase the demoralisation which will already have been produced, by utilizing the maximum available force. On the other hand, if a small enemy formation be encountered, the formation leader may decide to attack with only a small portion of his force. This will generally be the lowest sub-formation, and while it delivers its attack, the remainder will patrol above ready to deal with further opposition.

101. Decoy tactics are sometimes successful and may be usefully employed against an enemy numerically superior. Thus, by alternately attacking from long range and retreating, some of the enemy sub-formations may be induced to pursue until out of reach of their main body. A leader may detach one sub-formation to draw a hostile formation on to attack, while he retains the remainder at a greater altitude, ready to surprise the enemy should the apparent opportunity be seized. The sub-formation going down as a decoy must not be more than three or four thousand feet below the main formation or it will run the risk of being attacked by superior numbers before the remainder can come to its assistance.

102. During an attack, if the hostile formation scatters, attention should be concentrated on the stragglers; and if they dive, only a portion of the force should pursue them, the remainder being retained as a protection against surprise from above.

General organisation of formations

103. The fundamental principles which apply equally to all air formations are laid down in Chapter II. Generally speaking the organisation of formations and sub-formations is dependent on the type of aircraft employed and on the duties which it is required to perform.

104. Air formations may be divided roughly into two classes, *i.e.* :—

(i) *fighting formations*, whose primary duty it is to fight and destroy the enemy's aircraft;

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(ii) *bombing or other formations* that have other duties, such as bombing or reconnaissance, to perform, whose immediate object should be to complete their mission and then return with the least possible delay to their aerodromes.

105. In enunciating the principles of air drill it is intended that this manual shall be treated as a guide rather than as a rigid textbook. The organisation of formations most suitable for war must vary according to the strength of the air opposition and the task of the formation.

106. A formation of single-seater fighting aeroplanes must be disposed in such a manner as to be able to develop the volume of concentrated fire against any objective which it may attack. A bombing or reconnaissance formation composed of two-seaters or multi-seaters with armament capable of developing fire to the rear, should fly so that individual aircraft in the formation can make the best use of mutual support in defence.

Fighting formation of five.

107. Though, as explained in Chapter II, paras. 17–20, the sub-formation of three usually forms the basis of all large formations during peace training, the fighting formation of five may often have to be adopted when there are five aeroplanes in a flight available for duty, or when the remaining pilots of a sub-formation which has sustained a casualty are absorbed in another.

108. The fighting formation of five is a V-shaped formation. Pilots Nos. 4 and 5 keep station on the quarter, and usually slightly above Nos. 2 and 3 respectively. The exact position of the two rear pilots is determined by the type of aeroplane which is being flown; for if they fly slightly above Nos. 2 and 3 they gain a tactical advantage and are able to maintain their positions more readily at all speeds, yet they may in certain types find their view obstructed by their own planes and engine, and be forced to fly at the same level in order to keep the aeroplanes in front of them in view.

109. If the leader becomes a casualty, his place will immediately be taken by No. 2, the deputy leader; while No. 4 moves up with No. 2 until he is level with No. 3; No. 5 either takes station in the centre of the rear rank, or, alternatively, remains in his original position. Which position he will adopt will depend on the type of aeroplane and the nature of the operation.

Larger fighting formations

110. Larger fighting formations are based on the principles laid down in the preceding paragraphs and may consist of any number of sub-formations, the exact composition and disposition of which will depend upon the exigencies of the occasion.

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111. As an example of a larger formation peculiarly suited to single-seater fighters the following may be adopted. The formation generally consists of three sub-formations of three or five, each flying in "Vee" formation, the leader of the leading

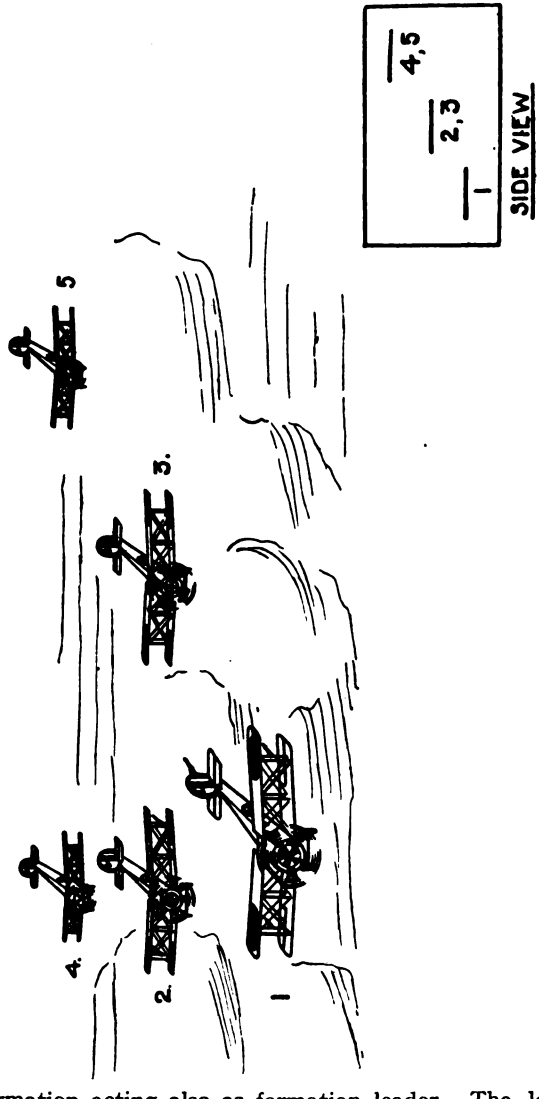

FIG. 23.—FORMATION OF FIVE.

sub-formation acting also as formation leader. The leader of the second sub-formation should fly about 500 feet above, and the leader of the third sub-formation about 2,000 feet above the formation leader.

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112. It is the duty of the leader of the third sub-formation to watch both the formation leader and the second sub-formation; he must be within striking distance of both, but should be some way astern, so as not to discourage the enemy from attacking the lowest sub-formation. In this way a skilful leader can often draw hostile aircraft into a trap.

Bombing formations

113. The considerations which affect the disposition of aircraft in bombing formations are somewhat different from those which influence the organisation of fighting patrols. It is in the first place of great importance that pilots should keep station so that the leader and other pilots may be kept constantly in view of each member of the formation; but, at the same time, the formation should be so organised as to be able to develop the maximum field of fire in any direction, particularly to the rear.

114. Bombing formations or formations engaged on other similar duties are required to perform their missions and return to their aerodrome as speedily as possible; they are thus often compelled to fight long rear-guard actions, and must, therefore, be so organised that no attack can be launched against them from any direction without exposing the aggressor to the concentrated fire of several guns.

115. Just as the exact inter-spaces between aircraft organised for fighting must vary with each type, the most favourable organisation for a bombing formation will depend primarily on the field of view obtainable by both pilot and observer, and also on the effective range of the armament carried.

116. Bombing formations rarely consist of less than nine aeroplanes and are generally composed of a number of sub-formations of three. If a formation becomes disorganised owing to hostile interference, these sub-formations retain their cohesion and afford each other mutual support.

Bombing formation of Nine

117. This formation consists of three groups of "three" and is suitable for aeroplanes in which the pilot possesses a good forward view. The leading "three" is composed of the formation leader, followed by Nos. 2 and 3 who fly on each quarter but about 25 feet above him. The second sub-formation consists of the deputy formation leader who keeps station astern and to the starboard, and not less than fifty feet above and as close to the formation leader as possible without losing sight of him, being followed by Nos. 5 and 6, flying on the same level but on either quarter. The third sub-formation (Nos. 7, 8 and 9) flies astern of the leading sub-formation and to the port, level with the second sub-formation.

118. This formation is extremely difficult to attack at close range; for, if it be approached from astern and below, the observers in the foremost aeroplane obtain a clear field of fire,

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unobstructed by their own tail planes; whereas if an attack is delivered against the leading sub-formation, the pilots in rear can dive and use their front guns against the enemy.

119. The necessary difference in altitude between pilots is proportionate to the distance between them. It should be as small as possible so as to avoid the contingency of pilots in the rear rank losing sight of the aeroplanes in front of them, their view being obstructed by their own planes. The closer one pilot flies to another, the less difference in altitude there must be in order that the leader may be seen and his slip-stream avoided.

120. With some aeroplanes the downward view is restricted by the planes, and it is preferable for the rear rank of the formation to fly below the leader so as to give the pilots astern a good view between their top planes and fuselages. This alteration in disposition, however, possesses the disadvantage that it exposes the rear aeroplanes to an attack from below and astern without being covered by the fire of all the observers in front.

121. In nearly all types of day bombing formations it is essential that all aeroplanes should be kept as close together as possible, both as regards altitude and distance. Aeroplanes flown by experienced pilots are not too close within 20 yards of each other during an engagement, and a difference in altitude which allows 10 feet between the top plane of one aeroplane and the wheels of another is quite sufficient to ensure clearance of the slip-stream of an aeroplane 40 or 50 yards in front.

122. Close formation has two essential advantages :—

(i) It places an attacker within very effective range of all the aeroplanes in the formation.

(ii) It renders it impossible for a hostile pilot to force his way through the formation and thus enables all pilots and observers to repel the attack by fire, without danger of hitting each other.

Importance of co-operation

123. The success of a formation in battle will depend largely on the effective co-operation of its component parts, which can only be achieved as the result of mutual confidence and practice.

124. During a severe engagement, as the result of which both sides suffer numerous casualties, cohesion will be greatly facilitated if the sub-formations of three which form the basis of a formation maintain their organisation. The pilots of these sub-formations should never lose sight of each other and should generally concentrate against the same objective. As soon as the battle has terminated, or the formation leader issues the order to reform, these sub-formations will collect, each sub-formation joining on to the next until reorganisation is complete. Isolated pilots should endeavour to form up with any other pilot or sub-formation.

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125. When a formation is subjected to heavy fire from the ground, the leader may occasionally alter course in order to confuse the enemy's range-finders; but any tendency on the part of individual pilots to fly an irregular course should be checked, as this tends to disorganise the formation and afford hostile aircraft the opportunity of a concentrated attack against an isolated portion of the force.

126. The leader should invariably check his speed before initiating a fresh manœuvre, and should issue a warning signal whenever he meditates a change of direction, so as to allow his formation to close up.

127. The ability to replace casualties without becoming disorganised is of primary importance. If both leader and deputy leader have been forced to drop out, the next senior pilot should take over command.

128. No pilot should leave the formation on his own initiative to attack hostile aircraft, however favourable the opportunity may seem ; it is his duty, however, to warn the leader of the presence of any enemy which appears to have escaped notice.

129. In a general engagement, the breaking-up of a formation is sometimes inevitable; it is therefore of the utmost importance that definite instructions as to rallying and reforming after a battle should be issued and understood by all.

Responsibility of a leader

130. The duty of the leader of a formation in battle consists, not in gaining a personal victory over a hostile pilot, but in achieving decisive success with the force which he commands. His responsibilities during the battle include the following :—

(i) To lead, direct and control the formation.
(ii) To manœuvre for position.
(iii) To decide when to attack.
(iv) To decide when to withdraw the formation with a view to reorganising.

131. It should be clear to the commander of a formation that his mission is not so much to fight as to lead his force to the attack; and having initiated the battle he should keep in touch with the progress of the fight and be prepared to render assistance to any of his pilots who may be in difficulties. If a change occurs in the tactical situation, such as the arrival of hostile reinforcements, he must be capable of withdrawing his formation with the object of re-forming or of gaining height.

132. A leader is responsible for the security of his command. He must watch over his pilots and know where they are and what they are doing. He must be able to realise the capabilities of some and the weakness of others, and must estimate the fighting power of his formation as a whole. Before deciding to attack, he should note the altitude, numerical strength and organisation of the enemy, and should not forget that an error on his part

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in overlooking other hostile formations in the vicinity may seriously jeopardise his chances of victory.

133. The leader should regulate his approach in such a manner as to arrive with all his pilots together, and should regard the stern of his formation as his own tail and guard it accordingly.

134. During an engagement, the enemy may detach a sub-formation or even a single aeroplane which will endeavour to climb to a higher altitude with the object of resuming the attack at a tactical advantage. As soon as the leader becomes aware of this manœuvre, he should counter it by climbing to a higher level with a sufficiently large force to deal with the hostile detachment. The duty of preventing hostile detachments from climbing out of a battle to gain a tactical advantage may, by pre-arrangement, be delegated to a subordinate, so as to leave the formation leader free to control the decisive attack.

REAR-GUARD ACTION

General principles

135. Although in air fighting the offensive spirit is essential, there are many occasions upon which rear-guard action may become necessary owing to the nature of the mission which is being performed. Moreover, owing to the fact that limited fuel capacity forces an aeroplane pilot to return to his aerodrome after the lapse of a certain length of time, he may be compelled to retreat in order to avoid the possibility of a forced landing.

136. The methods to be employed in fighting a rear-guard action must necessarily vary according to the type and number of aircraft engaged in the battle, and will depend on the mission, the performance of which is the immediate object of the flight; but there is one rule which is applicable to all methods, viz. :— "The best method of defence is to employ aggressive tactics." This does not mean that an isolated pilot, or even the leader of a formation, should fly out of his course to attack any enemy observed in the sky, but that whenever an encounter is imminent, the enemy should be met and fought in the same spirit as that which animates the attack, *i.e.*, the determination, not merely to drive him away, but to defeat and destroy him. It should not be forgotten that the attacker invariably possesses a moral advantage, though his advantage may to a large extent be nullified if he be met with determination and, when his attack has failed, counter-attacked with vigour.

Individual rear-guard action

137. Owing to lack of armament aft, a single-seater pilot forced to fight a rear-guard action is extremely vulnerable, since he can only use his guns by turning to face his aggressor. The nature of his mission, or lack of fuel, may compel him to fly towards his aerodrome, but, even if he is attacked by superior numbers, his best defence is to counter-attack with such skill and determination that the enemy may leave him to resume his course unmolested.

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138. A good method of counter-attacking an enemy diving from astern, is to turn suddenly in his direction and, as he flattens out to avoid a collision, fire up at him, and then execute a climbing turn on to his tail.

139. If attacked from below, a sudden zoom and turn, executed so as to terminate in a dive on to the enemy's tail, may often be successful. Care should be taken to carry out this manœuvre so as to surprise the attacker, otherwise he will counter it by changing direction.

140. A single-seater pilot who runs out of ammunition, or finds himself with his guns out of action, can defend himself only by manœuvre. If attacked by a pilot flying a similar type of aeroplane, he should endeavour to outclimb his attacker. If the attacked pilot fails to outclimb his opponent, he may succeed in out-manœuvring him by keeping at the same altitude and flying parallel to him, so that the opponent, unless he possesses great advantage in speed, will not be able to gain a firing position without turning and losing distance. By manœuvring skilfully in this manner and seizing every opportunity afforded by the enemy to edge closer to friendly territory, a retreat may be successfully achieved.

141. An infallible rule is never to dive straight away from an opponent, as by doing so, the attacker obtains an easy shot even if outdistanced.

142. If there are clouds about, an enemy may be shaken off by diving into them. It is not advisable to spin unless over clouds, as a straight dive is necessary to regain control, when the attacker, if he has followed, will obtain a perfect shot.

143. A quick climbing turn, carried out generally with too much rudder, is the best method of escaping from an unfavourable position, since this manœuvre does not entail loss of height, which would afford the enemy the opportunity of resuming the attack with a tactical advantage. A pilot, even when short of ammunition, may succeed in driving off a hesitating attack, by showing a bold front.

144. If a pilot is forced to abandon the combat when flying at a low altitude, the best method of escape is to go right down and fly back on a zig zag course as close to the ground as possible. Even a determined attack may be driven off by skilful flying and by dodging round obstacles such as trees and houses.

145. A rear-guard action is more easily fought with a two-seater aeroplane owing to its ability to develop fire astern, and success will depend very largely on the skill and alertness of the back gunner whose primary duty is to avoid being taken by surprise.

146. Although the general tactics, described above, to be adopted by a single-seater pilot in fighting a rear-guard action apply equally to a two-seater pilot, the object of the latter when attacked should be to manœuvre so as to disturb the enemy's aim, and at the same time to facilitate the fire of his own back-gunner, while being himself ready to seize any opportunity that he may be afforded of destroying the attacker with his front gun.

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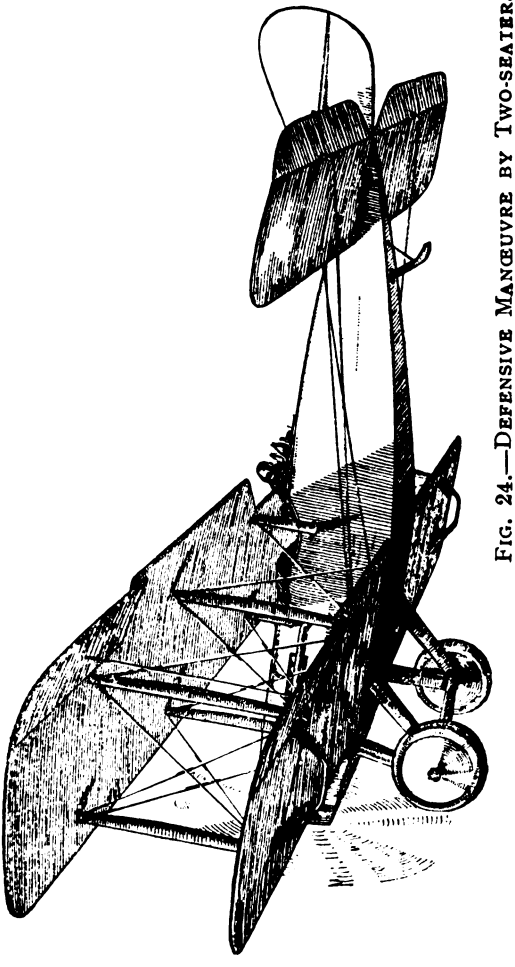

FIG. 24.—DEFENSIVE MANŒUVRE BY TWO-SEATER.

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147. For a two-seater pilot to dive or spin away from an enemy is just as fatal as it is for a single-seater to do so, since in these positions the back gunner is hindered in the use of his weapons. On the other hand, an upward spiral affords the gunner an opportunity of firing and renders the attacker's target extremely difficult to hit.

148. The same fire tactics as are laid down for the pilot apply equally to the gunner, except that as the latter is generally provided with a larger quantity of ammunition he can use his gun more freely and open fire at longer ranges. A gunner should, however, delay the opening of fire until the enemy arrives within effective range; otherwise he will merely expend ammunition without result.

Collective rear-guard action

149. The ability to fight a successful rear-guard action depends, for all classes of pilots on well disciplined formation flying (*see* Chapter II). Once a formation has become disorganised, especially in the face of superior enemy forces, the leader will experience difficulty in collecting his scattered force, and the enemy will thus be afforded the opportunity of destroying the formation in detail.

150. A defensive measure which may be employed when a formation is fighting a rear-guard action against superior numbers is the "Circle." When the attack becomes imminent, the leader makes a pre-arranged signal and commences a turn, whereupon the remaining pilots close up in single file behind him. The leader gradually reduces the size of the circle until he is flying close to the tail of the last aeroplane in the formation. (*See* Fig. 25.)

151. The leader of a formation which is attacked by superior numbers from above, should warn his pilots to hold themselves in readiness for a sudden change of direction as soon as he observes the enemy's approach to be imminent. As the hostile leader dives, a sudden turn in his direction should be executed; if the change of direction is carried out at the right moment, the hostile formation will overshoot, leaving itself open to a counter-attack.

152. If a formation of single-seaters is heavily engaged astern, the pilots in rear can dive under their own formation so as to afford their leader an opportunity of counter-attacking the enemy should the latter attempt to pursue.

SPECIAL MISSIONS

General principles

153. Although the general principles of air fighting, both in attack and defence, are applicable to all types of aeroplanes, it may often be necessary to employ aircraft for duties other than fighting, and combat should not then be sought. Thus, whether a formation is ordered to carry out an important reconnaissance,

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to bomb a particular objective, or to obtain photographs of a certain locality occupied by the enemy, it is obvious that the fulfilment of the duty in hand should be the primary consideration. On the other hand, the execution of a special mission in the face

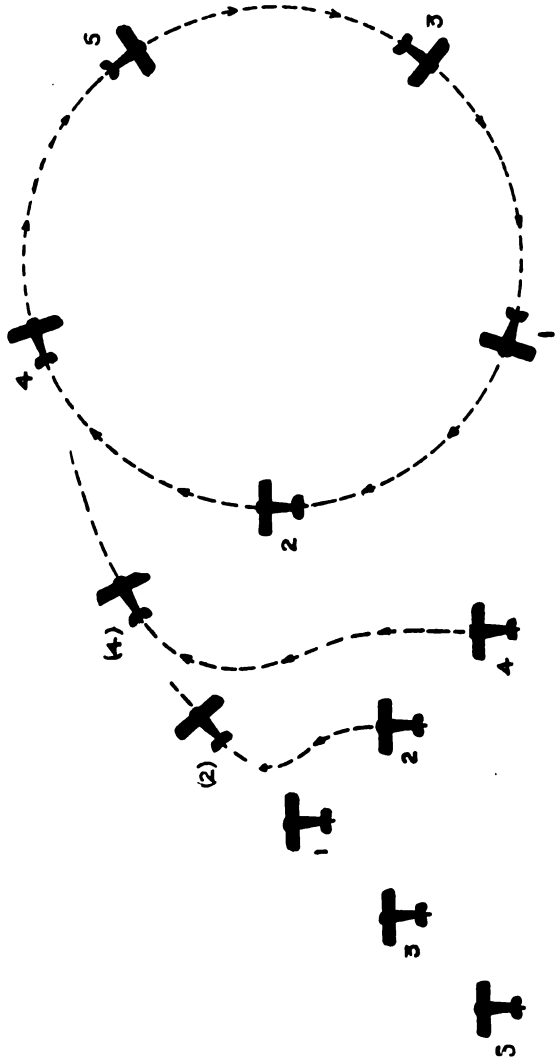

FIG. 25.—FORMING DEFENSIVE CIRCLE.

of a hostile air force will not generally be possible without fighting, and it is therefore essential that the formation undertaking it should be organised for defence.

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154. Determined and skilful leadership combined with good formation flying may cause the enemy to delay their attack in the hope of obtaining reinforcements, and thus time may be utilised to accomplish the duty in hand. On the return journey, speed, fire discipline and good marksmanship, and the ability to retain cohesion during a rear-guard action, should enable the formation to regain its aerodrome even if attacked by superior numbers.

Escort duty

155. An escort to a formation engaged on a special mission is seldom employed, since better results are as a rule obtained by sending out patrols of fighting aeroplanes to operate independently over the area where opposition is most likely to be encountered. Offensive patrols in these circumstances must endeavour to act with great vigour, so as to attract the attention of any of the enemy's fighting aircraft that may be in the vicinity.

156. Should an escort be provided, its primary duty is to enable the reconnaissance or bomb-raid to accomplish its mission, and it should only fight in execution of this duty.

157. The reconnaissance or bombing aircraft should fly in a separate formation and should be capable of dealing with any minor opposition which they may encounter; the escort being there merely to attack and drive off hostile offensive patrols which may seek to interfere with the duty in hand. The escort should generally fly above the aircraft to be protected, in such a position as to obtain the best view of them, and at the same time have freedom of manœuvre in any direction.

158. It is essential that the fighting formation should not allow itself to be drawn away by the enemy; and it may sometimes be necessary to organise the escort in two sub-formations, one of which can be employed to attack and disperse any of the enemy's aircraft that may attempt to approach while the other continues to act as close escort.

Bomb raids and special reconnaissance

159. The duty of formations engaged in bombing and special reconnaissance is to reach their objective and return with the least possible delay. The secret of success lies in good formation flying, and in the ability to fight a rear-guard action; the primary object being to prevent the enemy from delivering a concerted attack against one or two aeroplanes at a time, and thus destroying the formation by a series of isolated engagements.

160. A formation which has been carefully trained and is capable of flying in close order, even in difficult circumstances, should be able to cope with any normal opposition and to inflict such heavy losses on the aggressors that they will hesitate to renew the attack. By a careful disposition of his aircraft, and by skilful manœuvring, a leader should endeavour to bring a superior number of guns to bear against the enemy aircraft from whatever direction the attack may be delivered.

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161. It is essential that pilots should be able to retain their positions even on fairly sharp turns, since the enemy will usually attempt to attack while the formation is changing direction. In close formation, even on a simple turn (*see* Chapter II), it is not easy to avoid disorganisation, because the pilots on the inner flank of the turn tend to over-run the leader and those on the outer flank to lag behind.

162. As soon as the cautionary signal for change of direction (*see* Chapter II) is observed, pilots on the outer flank should increase their speed so as to retain their station, while those on the inner flank should check their speed slightly, and throttle down so as to avoid gaining height. During the turn, pilots on the outer flank should keep as close to the leader as possible so as to shorten their course, and should open the throttles of their engines sufficiently to keep in position. Pilots on the inner flank should be careful to apply enough bank so as to avoid skidding into the formation. When commencing a turn, they should change direction rather more sharply than the leader, so as to make sure of not getting in his way (*see* Figs. 11 and 12). At one point in the course, the pilot on the inner flank is somewhat separated from the remainder, but this is only a slight disadvantage since an attack will generally be delivered against the outer flank; moreover, should the enemy attempt to approach the inner flank he can easily be countered by the leader turning in his direction.

163. The Squadron Commander should assemble the pilots and observers shortly before they leave and make certain that no further information is required and that all obscure points have been made clear. He should also give his final instructions as to time and the policy to be adopted, under the prevailing weather conditions. He should define the rendezvous most carefully both as regards height and locality. He should arrange for spare aeroplanes as substitutes for any which develop faults at the last minute. He should make a point of informing the sub-formation leaders concerned of any alterations which he has made. For long raids, it is most necessary that the pilots and mechanics should work with smartness and precision to avoid unnecessary waste of petrol in running engines on the ground.

164. When all engines have been run up, pilots and observer should assemble for final instructions, and the interval should be used for any necessary adjustments, or, if the raid is a very long one, for replacing the petrol used in the first engine test. Pilots should finally get into their aeroplanes to restart engines at least 10 minutes before the time for leaving the ground, so as to allow for emergencies. Mechanics should be instructed to start engines in the order in which they are to leave.

165. If two or more formations are to leave the same aerodrome, sub-formations should leave the ground in reversed raid order, so that the rear formation will have a little height in hand and be able to form easily on those in front. If there is sufficient space on the aerodrome, aeroplanes should be taxied out in order, and

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formed up on the ground in their flying formation. As many as possible of the formations of a raid should form up before any one of them takes off, in order to waste as little time as possible between the start of formations. If space prevents this, as many aeroplanes as possible should be taxied out, and the remainder should be faced so as to move in order as soon as the way is clear.

166. On all raids, it is desirable to get to "working height" in good formation as quickly as possible. Leaders should decide on an altitude (usually 1,000–2,000 feet below working height) at which they consider formation should be closed so as not to lose efficiency in keeping close formation while climbing. When two or more formations are to rendezvous, an altitude should be decided upon for assuming raid order, and this altitude should be considered as the working one. After leaving the ground, the formation leader should climb in wide circles at the rate at which he can best keep in touch with the remainder of the formation. The remaining pilots should attempt to climb above and keep close to him, so as to show him that they can easily keep position and thus encourage him to climb at his maximum speed. Each pilot should climb at what he considers is the best speed for his aeroplane, and only attempt to get into position by taking the inside course on turns. On reaching the height arranged for closing, every pilot must do his best to get into position. The leader should now disregard aircraft which are above, and therefore easily able to take position, and turn so as to allow stragglers to close up. He should fly level, at just below his best climbing air speed, so as to allow those behind and below to continue at their best climb and overtake him. If he flies at too low a speed, he merely causes inexperienced pilots to climb too steeply and lose efficiency. The leader should not wait for obviously inefficient stragglers long enough to endanger the success of the raid. Their places should be taken by emergency aeroplanes. Even if their places have been so filled, stragglers must attempt to regain their places as long as the formation is flying over friendly country, in case the leader should decide to wait for them so as to fill gaps caused by other pilots falling out; similarly, emergency pilots if not required, should stand by in case of gaps occurring at the last moment in their own or another formation taking part in the raid.

167. As soon as the formations are ready, the leader should cross the lines so as not to waste time. When travelling to and from the target, the leader must set the best possible speed consistent with good formation flying. Under anti-aircraft fire it may be advisable to make occasional and irregular alterations in the course with the object of confusing the enemy's anti-aircraft gunners; but violent changes of direction which tend to disorganise the formation should be avoided.

168. After passing the target, the leader should throttle down until he is satisfied that the formation has closed up.

169. On the return journey, formation should be maintained until the aerodrome is reached, and pilots should land in the order in which they took off.

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FIGHTING BY NIGHT

General remarks

170. Air fighting at night may be divided into offensive and defensive operations in so far as it takes place either over the enemy's country or is carried out over friendly territory, where it depends for its effect upon the co-operation of a ground organisation consisting of sound ranging sections, searchlights and anti-aircraft guns.

171. Owing to the difficulties experienced in locating hostile aircraft in the darkness, offensive night fighting operations are generally confined to areas such as enemy aerodromes over which an encounter with hostile craft is more likely.

172. In defensive operations to facilitate co-operation between aircraft and ground troops, the area to be defended should be divided into sectors each of which may then be allotted to a night-flying unit. Each sector should have a front towards the probable attack of not more than 7 miles, and should contain at least one prominent landmark such as a distinctive shaped wood or lake which can be easily recognised or, failing this, have a flashing lighthouse stationed in it.

Defensive fighting

173. The chances of encountering aircraft in the dark are small, and defensive night fighting depends for its success on efficient co-operation between pilots and the personnel in charge of searchlights and anti-aircraft guns.

174. When a pilot observes hostile aircraft held in a concentration of searchlights he should signal to the anti-aircraft gunners his intention of attacking by flashing a series of dots on his signalling lamp. Upon receipt of this signal, anti-aircraft guns should cease fire, but searchlights should continue to hold the enemy aircraft in their beams.

175. An experienced searchlight crew can generally estimate the approximate altitude at which a hostile aircraft is flying, even if they fail to illuminate it at once; pilots should, therefore, estimate the altitude of the first apex of beams and climb or descend to that altitude whilst searching.

176. In order to intercept hostile aircraft which may be attempting to cross over into friendly country, a system of continuous patrols should be instituted, each patrol being so organised as to keep the maximum area under observation. The number of aeroplanes employed at the same time to patrol one sector, will vary according to circumstances; but it will usually be necessary to arrange for pilots to patrol at different altitudes.

177. Pilots should limit their activities to their own sector and should on no account leave it to search a concentration of searchlights in another area.

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178. The duration of patrols, the altitude and the area to be patrolled and the tactics to be employed when hostile aircraft are sighted, require careful defining so as to avoid the risk of collision. Night patrols exert a considerable strain on pilots and should not exceed two hours duration.

179. It is easier to distinguish a hostile aircraft from below, especially if it is only lit up occasionally by searchlights rays; yet on the other hand, provided that the enemy can be kept in view, the pilot attacking from above is at an advantage.

180. On dark starlight nights it is possible to distinguish an aircraft as far off as 200 yards, and on a bright moonlight night as far as 600 yards, although at these distances all that can be seen is a dark shadow.

181. An aeroplane with a stationary engine will often betray its presence by the shower of sparks which are emitted from the exhaust. These are sometimes mistaken for tracer bullets.

182. Aircraft are identified at night by the appearance of their silhouettes; pilots should, therefore, make a careful study of the silhouettes of all enemy and friendly aircraft.

Offensive fighting

183. Owing to the difficulty experienced in locating aircraft at night without the assistance of searchlights, it is usually best to stand by until intelligence reports of hostile air activity are received. These reports may be obtained by kite balloon observation, by information supplied by reconnaissance pilots flying over the enemy's country or by reports from advanced troops or observation posts.

184. As soon as information has been obtained as to which hostile aerodromes are active, the patrol should be sent off to one of them and should remain in its vicinity until the hostile aircraft, on their return from their mission, disclose their presence by switching on navigation lights or by endeavouring to signal to their aerodrome, when they can be attacked.

185. The moral effect of destroying hostile aircraft over their own aerodrome is very great, and this is increased by attacking the hangars, anti-aircraft defences and searchlights, especially if the attackers are armed with light bombs which can be released as soon as a hostile aeroplane is seen to be attempting to land. Two-seater aeroplanes in which the observer can use his gun while the pilot is occupied in manœuvring the aeroplane are better suited to this form of attack than single-seaters, since diving near the ground is rendered more difficult at night owing to the dazzling effect of searchlights and the flash produced by the attackers' own guns.

Individual attack

186. When hostile aircraft are sighted, the object of the attacker should be to approach within decisive range without disclosing his presence. The most suitable position from which

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to deliver the attack on an aeroplane is from astern and slightly below the tail-plane of the enemy.

187. Fire should not be opened until the attacking pilot is close enough to distinguish the outline and principal characteristics of his opponent; this will ensure :—

(i) that fire is opened at effective range;

(ii) that a friendly aircraft is not attacked by mistake;

(iii) that a friendly aeroplane, engaged in attacking the same opponent, is not hit by wide shots. Every effort should be made to take steady aim and to ensure that the first burst of fire strikes the hostile aircraft in a vital spot. Coolness and self-control will be required to overcome the tendency to open fire erratically or at indecisive ranges.

188. It is essential to identify the aircraft about to be attacked without possibility of error before opening fire, as a friendly aircraft may easily be mistaken for an enemy in the dark at long ranges.

189. If the first burst of fire fails in effecting its object, the opportunity to destroy the enemy will often be lost, as the flash of his machine gun tends to dazzle the attacker and thus facilitates his opponent's escape.

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CHAPTER IV

ATTACK OF AIRSHIPS AND KITE BALLOONS.

GENERAL PRINCIPLES

Introductory remarks

1. The attack of lighter-than-air craft forms one of the rôles in which all fighting aeroplanes may be employed, and it is therefore essential that pilots in fighting squadrons should be acquainted with the characteristics of these types of aircraft and should be instructed in the methods which should be adopted to destroy them.

2. Aircraft lighter-than-air may, for purposes of air fighting, be divided into two main classes, *i.e.* :—

(i) Airships.
(ii) Kite balloons.

The tactics which fighting pilots should adopt in attacking these craft will naturally vary according to the type of the enemy aircraft and other circumstances, but certain general principles can be laid down which are based on experience.

3. Airships are generally employed for long reconnaissance or for bombing attacks. Their radius of action may be considerable; for they are able to travel not only under their own power, but, by varying their altitude at will, they can make use of favourable air currents and thus economise fuel. They are generally armed with machine guns or even heavier armament, but owing to their large size, comparatively low speed, and inadequate power of manœuvre, can only adopt defensive tactics against aeroplanes. By losing ballast they are capable of climbing at great speed and are thus often able to escape from aeroplanes whose ability to climb is limited.

4. Kite balloons are utilised chiefly for reconnaissance, owing to their ability to remain stationary at altitudes up to and over 6,000 feet, and provide suitable observation posts for personnel acting in co-operation with naval or military forces; they are also sometimes employed for the purpose of forming an anti-aircraft curtain. They can be raised and lowered from the ground by mechanical means, but are not generally provided with armament, their defence being undertaken by the personnel on the ground. Owing to their vulnerability to aeroplane attack, kite balloons are generally heavily defended from the ground by anti-aircraft guns and machine guns and are therefore difficult to approach.

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Special considerations

5. The general principles of air fighting stated in Chapter III, para. 3, apply to a large extent to this branch of warfare; but, owing to the characteristics of lighter-than-air craft, the tactics to be employed are somewhat different.

6. Surprise in the case of an aeroplane attacking a lighter-than-air craft is of great importance. A pilot who has failed in his attempt to surprise the enemy will rarely be afforded a second opportunity to attack when the opponent is either a balloon or an airship.

7. Owing to the comparatively large size of lighter-than-air craft, it is a common error for aeroplane pilots to under-estimate the range to the objective and open fire at long ranges, with the result that owing to machine gun stoppages or lack of ammunition before they reach decisive range, the opportunity for destroying the craft is lost.

TRAINING

General instructions

8. Training should commence with camera gun practices, the pupil being sent up to approach a kite balloon. The instructor will criticise the method of approach employed by the pupil and the range at which the latter opened fire, the criticism being assisted by the camera gun films.

9. Pupils should be taught how to approach the objective by flying low, or by diving down from an altitude, care being taken to check any tendency they may have to open fire before decisive range has been reached.

Essentials to success

10. It is of the utmost importance that pilots should be trained in estimating the distance between themselves and their objective when approaching at high speed; since, owing to the large size of the target, pupils require considerable practice before they can attain proficiency.

11. Training is best carried out by making pilots use the camera gun and checking the range at which they open fire. It should be pointed out that a few rounds fired from a range of 100 yards or less are more effective than hundreds fired from a distance.

ATTACK OF KITE BALLOONS

General principles

12. The best method of approaching a hostile kite balloon will depend to a large extent on weather conditions, on the position of the balloon previous to the attack and on other circumstances, but the tactics employed can be roughly sub-divided as follows :—

(i) Attack against a kite balloon, over 3,000 feet.
(ii) Ground attack.
(iii) Cloud attack.

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13. A kite balloon which is stationary in the air can be hauled down very rapidly by mechanical means, and an attack will generally be anticipated by the ground personnel if a hostile aeroplane is seen approaching at a fairly low altitude. A pilot should, therefore, approach his objective at a considerable altitude until he arrives in the vicinity of the hostile balloon and then dive steeply at the greatest speed his aeroplane will stand. No time should be lost, otherwise the balloon will have been hauled down to the ground, or at any rate to within effective machine-gun range of the balloon defences, before the attacking pilot arrives within striking distance.

14. In order to defeat the vigilance of a kite-balloon section which has already become apprehensive of attack owing to casualties, it may be necessary for the attacking pilot to make use of some stratagem. For instance, the attacker may approach at a considerable altitude and then, when subjected to anti-aircraft fire, pretend to be hit and lose height as if falling out of control; if this ruse is successful in disarming suspicion, it may be possible to arrive within effective range without further opposition on the part of the enemy.

15. A kite balloon which is on the ground or at a low altitude should generally be approached by flying as close to the ground as possible. By this means a skilful pilot is able to take advantage of any cover afforded by ground obstacles, such as hills, trees or houses, and by the rapidity and suddenness of his approach presents an extremely difficult target to anti-aircraft gunners and to troops firing from the ground.

16. In cloudy weather it will sometimes be found possible to approach the objective unobserved by making use of the scattered clouds which appear in the sky during certain atmospheric conditions.

17. The altitude at which a kite balloon is flying can be gauged from a distance by climbing until the balloon appears to be in line with the horizon, when its approximate altitude will be shown on the altimeter of the aeroplane.

The attack

18. When closing in on the balloon, it is generally best to approach from leeward, for in this position the balloon affords a more vulnerable target. (*See* Fig. 26.)

19. Once a pilot has selected his target and determined on his line of approach, he should concentrate every effort on estimating the right moment to open fire, the object being to hit the hostile balloon with the first few rounds.

20. In order to set a balloon on fire, it is necessary to pierce it several times in a small area, so that the gas escaping from the holes forms with the air an inflammable mixture which is readily ignited by incendiary bullets.

21. When destroying a balloon, every effort should be made to kill the observer; since trained personnel is more difficult to replace than material. If there is any wind blowing, the observer

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suspended from his parachute will soon drift away from the protection of the balloon defences and can then be destroyed with impunity; but if the day is calm, no time must be lost in attacking him as soon as the balloon has been dealt with.

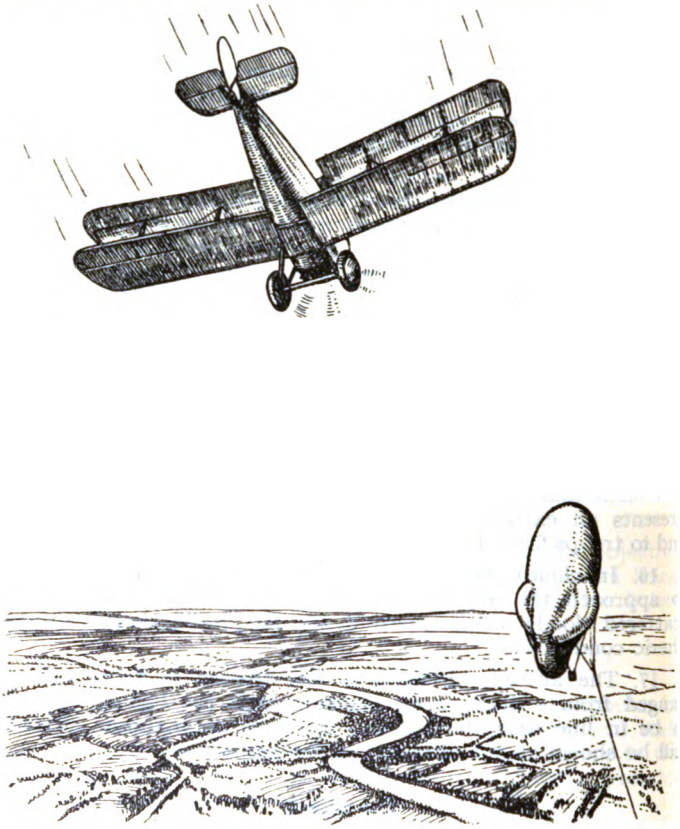

FIG. 26.—ATTACK ON KITE BALLOON.

The return

22. Before delivering an attack, the air should be scanned for hostile aircraft, since kite balloons are sometimes defended by aeroplanes specially detailed for that purpose, who will keep some distance away until they see their opponent intent upon his mission.

23. As soon as the balloon has been set on fire, the attacking pilot should either execute a steep turn and fly back along the ground, or he may climb to a higher altitude before returning.

24. It is inadvisable to remain in the vicinity of a balloon in order to ascertain the result of the attack, as a considerable

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nterval may elapse before the envelope bursts into flame after being hit, and meanwhile the attacker will be subjected to concentrated fire from all the anti-aircraft defences.

25. A climb should be executed to leeward, whenever possible, as the wind will assist the pilot in getting out of range of the balloon defences.

THE ATTACK OF AIRSHIPS

General principles

26. Owing to the large target they present to anti-aircraft gunners, airships do not generally operate over hostile territory by day. They may be employed, however, for naval reconnaissance, and when engaged upon this duty should be sought out and destroyed by aeroplanes.

27. Airships can operate at high altitudes and can be navigated through clouds and fog; they are capable of climbing at great speed especially after releasing bombs or ballast, and are generally well defended with machine guns and other armament. They are able to take advantage of clouds to remain concealed for considerable periods, owing to their stability and the power they possess of remaining stationary.

28. The outer envelope of an airship encloses a number of smaller envelopes called ballonets which are filled with hydrogen gas. This gas is in itself non-inflammable until mixed with air, with which it forms an explosive mixture.

29. An airship may be destroyed either by firing at and setting fire to its petrol tanks, or by puncturing one of the ballonets in the envelope, thus forming with the air admitted an explosive mixture, which is ignited by incendiary bullets.

30. At night, airships are generally engaged by fighting pilots acting in co-operation with searchlights and anti-aircraft gunners. The tactics employed in night fighting are described in Chapter III (paras. 170–189).

The attack by day

31. Unless there are clouds which can be utilised as cover to conceal the attack, it is generally preferable to approach an airship from below so as to avoid being silhouetted against the sky.

32. The attacking pilot having arrived within range should manœuvre into a favourable position, preferably astern and beneath the airship. Owing to the size of the target, deflection shooting is not of much importance; though it is essential to maintain the aim against a definite mark so as to obtain a good "group."

33. As soon as the attacking aeroplane is observed by the crew of the airship, it is probable that heavy fire will be opened against it; this can to a certain extent be avoided if the aeroplane pilot shifts his position from one quarter to the other, always returning to the original point of attack.

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CHAPTER V

ATTACK ON GROUND OBJECTIVES WITH MACHINE-GUN FIRE AND LIGHT BOMBS

GENERAL PRINCIPLES

Introductory remarks

1. Aeroplanes, by virtue of their speed and mobility and the power they possess of attacking an objective both by dropping projectiles and by engaging it with their armament, confer upon a commander the ability to develop a sudden and unexpected attack against the enemy's vulnerable points. Moreover, air attack against objectives on land or sea, may be carried out either in co-operation with the other services and in their theatre of operations, or it may be directed against targets situated far behind the enemy's lines.

2. Successful operations carried out by formations of aeroplanes against ground troops or important tactical objectives, may exercise a decisive effect on the enemy's powers of resistance. If carried far into the enemy's country, ground attacks may produce such a moral effect as to influence the tactical disposition of his aircraft.

3. The best method of ensuring freedom of action to a formation engaged in ground attack, is to organise it in such a manner as to enable it to deal successfully with any minor interference by the enemy, while protection against organised attack is provided by patrols of fighting aircraft sent up to operate in the same area and at the same time.

4. The tactical employment of aeroplanes against objectives on land and sea may be divided into :—

(i) Heavy bomb raids, *i.e.*, raids executed by aircraft specially designed for the carrying and dropping of projectiles.

(ii) Torpedo attacks carried out by torpedo-carrying aircraft.

(iii) Light bomb and machine-gun attacks which may be carried out with any type of light aeroplane and are usually delivered from such an altitude as to ensure success in hitting the objective.

(i) and (ii) are dealt with in other manuals.

5. Light armament attacks against ground objectives are generally delivered by aeroplanes specially detailed for the

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purpose, and may be carried out either by individuals or by formations.

6. During moving warfare, or when ground activity in the enemy's territory is considerable, it will often be advantageous to maintain certain Royal Air Force units for the purpose of attacking any suitable targets as soon as reported. Such a target presents usually only a fleeting opportunity. The units detailed for this type of operation should, therefore, be situated as near the enemy's territory as possible, and should maintain a certain number of pilots and aeroplanes ready to take the air at a moment's notice.

Special considerations

7. In an attack against ground objectives, an essential to success is surprise. The method of approach should not therefore afford the enemy any indication of the objective nor allow him time to warn troops in back areas.

8. This form of attack is best carried out by groups of aeroplanes flying in very open formation and acting under the direction of a leader. Individual pilots should enjoy the fullest liberty of action and should not be forced to retain their position with relation to others; they should follow the leader, who will select the general direction of the attack and give the signal for the return, but, apart from this, their freedom of movement should not be hampered, and they should select and attack any suitable targets which they may find.

9. This system has the advantage that it confuses the enemy's ground troops, increases the moral effect of the attack, and disturbs the fire of the defence. Moreover, although close formation is unsuited to low flying, the fact that pilots act under one leader and keep within sight of one another, enables them to close in on each other should necessity for air fighting arise.

10. A single pilot, although he can more readily conceal his approach and thus reap the benefit conferred by surprise, should not generally be employed independently, especially if he is flying a single-seater aeroplane, for he is extremely vulnerable to attack from above, and owing to the fact that the enemy's attention is not distracted by other aircraft he is liable to be subjected to the concentrated fire of the defence.

11. Surprise may sometimes be achieved by approaching the target at a very low altitude. Under these conditions, however, the target is difficult to find.

12. The objectives to be attacked may either be left to the discretion of pilots who are sent into selected areas with instructions to engage certain suitable targets when the opportunity presents itself, or they may be pre-arranged. If the latter, orders for the attack of an objective are generally issued by a superior authority at whose headquarters all information of the enemy's movements, whether received from the air or from other sources, is centralized. As soon as information is received that a target of sufficient importance has presented itself, orders

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can be issued by telephone or wireless telegraphy to units which have been detailed to stand by for the attack.

13. In drawing up the orders for an air attack, the necessity for providing protection for the unit or units which are to carry out the operation may arise; though units will generally be organised so as to be capable of both attack and defence, low flying formations suffer from certain tactical disadvantages and must, therefore, generally be supported by other air force units. These disadvantages are :—

(i) The pilot's attention is centred on the ground and on retaining his position: he has, therefore, less time available to guard against attack from above.

(ii) When flying near the ground, a formation is at a tactical disadvantage when opposed to any hostile formation flying above it.

14. In arriving at a decision as to whether protective patrols are required to afford support to a formation sent on a low flying operation, the following factors should be given due weight :—

(i) The extent of air superiority in the theatre of operations.

(ii) The distance from friendly territory of the target to be attacked.

(iii) The type or types of aircraft engaged in the attack.

(iv) Weather conditions.

15. When aircraft are employed for attacking hostile infantry in the vicinity of their forward positions, the greatest care should be exercised to avoid any possibility of endangering friendly troops. In moving warfare, pilots should, before going into the air, be given the latest information received from all sources, and definite zones in which ground targets may be engaged.

Training

16. Low flying requires rapidity of decision combined with skill in execution. Training should be progressive, the pupil being taught first to fly over easy country and to accustom himself to finding his way when flying near the ground; later, he should be shown how to avoid obstacles and take advantage of cover, how to manœuvre near the ground, and how to fly so as to present the most difficult target to hostile ground troops.

17. Firing practice when flying low, or when diving from an altitude against both fixed and moving targets, should be given, every effort being made to develop a pilot's accuracy of aim. When diving at an objective, speed increases very rapidly; the time, therefore, during which a target is within effective range is extremely short. The altitude from which fire should be opened will vary according to the size and nature of the target, but should rarely exceed 600–800 feet. Pilots should be taught rapidity of aim, great importance being attached to the accuracy of the first burst of fire.

18. Bombing from low altitudes, when travelling fast and diving, is largely a matter of good judgment and experience, coupled with knowledge of the type of bomb employed. The action of the various types of fuzes fitted to light bombs should

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be carefully studied, and pilots should be taught to adjust their own bombs so as to be capable of checking the work carried out by subordinates. No fixed minimum altitude can be laid down at which a particular bomb can be released without risk to the aeroplane from which it has been projected; but the danger of being struck by fragments or of damage through "blast-effect" can be disregarded at altitudes of over 200 feet when small bombs are used.

19. Individual training will be followed by collective training flights and squadrons.

20. Advanced training will include practice attacks against a definite target which should, if possible, demonstrate the fire effect produced by the attacking formation.

INDIVIDUAL ATTACK

General remarks

21. Isolated action should seldom be resorted to. As explained in the preceding section, an attack carried out by a pilot flying alone, although it facilitates surprise, rarely produces sufficient effect to warrant the additional risk incurred. Individual attack, however, forms the basis of collective attack, each pilot acting to a large extent independently and benefiting more by the confusion of the defence than by the close support of his fellows.

22. If the enemy's lines are crossed at a low altitude, the nearer the pilot can keep to the ground and the more use he can make of ground obstacles to conceal his approach, the greater will be his immunity from machine-gun fire.

23. As soon as hostile territory is reached, an irregular course should be maintained so as to disturb the aim of the enemy's ground troops; this can best be achieved by changing direction constantly to one side or the other.

24. On arriving in the vicinity of the objective, height will generally have to be gained before commencing the attack; but care should be taken not to climb into position whilst under fire from the ground, thereby affording an easy target to the enemy.

25. Bombs should generally be released first, after which the pilot can return to the attack and use his guns.

26. The dive, which should generally be commenced from an altitude of under 2,000 feet, should be executed steeply in order that sufficient speed may accrue to carry the aeroplane away from the target with considerable rapidity on terminating the dive. The dive not only enables the pilot to bring his forward guns to bear on the target, but stimulates confidence and the spirit of aggression.

27. A certain reserve of ammunition should invariably be retained in case of need during the return journey.

Special considerations

28. When selecting a target for attack, the moral and material damage which is likely to result to the enemy should be taken into consideration; for instance, the attack of infantry in trenches will rarely produce more than a transitory moral effect, and the attacker will generally incur considerable risk himself whilst

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engaged in the attempt. Troops on the march, transport, ships conveying troops and other similar targets, on the other hand, will prove very vulnerable to air attack.

COMBINED ATTACK

Object

29. Raids by formation or by aircraft of different types are carried out with the object of achieving the maximum moral and material effect against the enemy's most vulnerable points. The object may also be to force the enemy to give battle in the air; since superiority of numbers in any given area is of little avail unless the enemy can be induced to accept battle in a locality and at a time chosen by the attacker. Thus, an enemy who persistently refuses to meet the air forces of his opponent in battle may be dealt with by organising raids against selected objectives in his back area. If these raids are repeated at fixed times during the day, the enemy will either be compelled to give battle or suffer in material and in *morale*.

30. The advantages of employing a number of different types of aircraft in support of each other is that the characteristics of each type can be used to the best advantage; the ultimate object aimed at being that a formation thus organised should be able to develop the greatest power of offence against aircraft as well as against ground objectives. Such raids consisting of composite forces should therefore generally be carried out by a formation consisting of :—

(i) Single-seater aeroplanes, possessing great power of manœuvre and being suitable for low flying.

(ii) Light bombers capable of speed, possessing the power of manœuvre and capable of descending to an altitude from which they can make certain of hitting the target. These aeroplanes should also be fitted with armament suitable for use against ground objectives.

(iii) Single-seater and two-seater fighter aeroplanes capable of dealing with the enemy's fighting organisations. Their primary duty is to protect the lower formations from above and behind, but provided that this is assured, they form a potential reserve for the attack of ground objectives.

31. Low-flying aeroplanes rely upon their speed and power of manœuvre, and on the effect of the surprise which they produce, to protect them against hostile action from the ground; moreover, by these characteristics and by their offensive action against ground troops, they protect both themselves and the units flying above them from fire directed from the ground. They are particularly vulnerable to attack from above.

32. Light bombers are capable of carrying a quantity of projectiles and of developing medium machine-gun fire in all directions; they afford local protection to low-flying single-seaters, while the latter protect them against the action of ground troops, and enable them to fly at an altitude which ensures success in hitting the target with their bombs. In their turn, however, the light bombers require support which is best afforded by fighting aeroplanes above them.

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33. The necessity of providing a force of fighting aeroplanes in the area to be attacked will depend on the number of fighting aircraft which the enemy is known to possess. Against an enemy that possesses a strong air force, a formation of fighting aeroplanes will have to be sent to operate over the area in which the attack is intended, in order to allow freedom of movement to the force detailed for action against ground objectives. The enemy's fighting formations, attracted by the opportunity of engaging aircraft occupied in trying to fulfil a special mission, flying below them, must be confronted with a force capable of meeting them on level terms. Against an uncivilised enemy or against a power that possesses only an insignificant number of fighting aircraft, the combined force should be capable of dealing with any opposition likely to be encountered.

Organisation of collective formations

34. The organisation of a composite force will necessarily vary according to the operation which it is intended to perform and the units available for duty. Broadly speaking, however, the aeroplanes with the best climbing performance should fly at the highest altitude and those that are easiest to manœuvre should fly nearest the ground.

35. Fairly clear weather should usually be chosen for an attack, otherwise units may find considerable difficulty in keeping touch with each other.

36. A composite force may consist of any number of squadron formations (*see* Chapters II and III), and will form up at a rendezvous which will be designated in operation orders.

37. Each squadron should fly at a pre-arranged altitude, keeping station at a fixed distance above and astern of the unit below; the leader of the leading formation acting as formation leader.

38. Each squadron should maintain its pre-arranged altitude until the force arrives within view of the objective, when the leading squadron should dive to attack, followed in succession by the remainder, except those units acting as offensive and protective fighting formations, which should remain over the objective until the force has re-formed and is ready to return.

39. Special pilots should be detailed to attack anti-aircraft guns and machine guns.

40. In order to avoid confusion and the risk of collisions, rear squadrons should reduce their speed when the objective is reached, so as to allow leading squadrons to dive and get clear, before they attack in their turn.

41. When pilots are required to circle round the objective so as to make full use of their machine guns, the direction of the circuits should be laid down in operation orders.

42. Each squadron, immediately it has carried out its attack, should fly to a pre-arranged rendezvous, re-forming, if possible, on the way. On reaching the rendezvous, squadrons should continue to execute right-hand or left-hand circuits as pre-arranged, until the whole force is ready to move off, when the leader should give the signal for the return journey.

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APPENDIX I

STANDARD ORDERS FOR NIGHT FLYING AT ROYAL AIR FORCE AERODROMES.

Section A—Control of Night Flying.

1. Night flying will be carried out under the supervision of an experienced officer known as the "officer in charge of night flying."

2. The whole of the lighting arrangements and the control of outgoing and incoming air traffic will be under the control of one officer, known as the "aerodrome control officer," who will be stationed in the vicinity of the first flare (*see* Section "B").

3. The position of the officer in charge of night flying must be known to the aerodrome control officer, and means of communication —whether by signal or orderly—must be available between these two officers.

4. The aerodrome control officer will have under his orders the following vehicles and the personnel in charge thereof :—

(i) Fire tender.
(ii) Ambulance.
(iii) Mechanical starter.
(iv) Trailer.
(v) Caterpillar tractor with strong wire cable for clearing the aerodrome of damaged aircraft, where this is available.

5. The aerodrome control officer must have the following equipment available :—

(i) Two signal cartridge pistols.
(ii) Signal cartridges of three colours.
(iii) Two signalling lamps, with long leads to batteries, complete with red and green screens.
(iv) Hand electric lamp.
(v) Six spare flares.
(vi) Eight red emergency obstruction lights.
(vii) Searchlight.

6. The aerodrome control officer will be supplied with a list of aircraft showing their distinguishing letters.

7. The officer in charge of night flying will be responsible for giving the aerodrome control officer any special instructions which may be necessary.

8. On large aerodromes or when more than one squadron is carrying out night flying a "despatching officer" may be appointed to assist the aerodrome control officer in marshalling aircraft at the taxying post. (*See* para. 12.)

Section B—Night Lighting of Service Aerodromes for Peace Training.

9. The direction of the wind and landing zone are denoted by six white lights placed in the shape of a T, the long arm of the T pointing directly down wind (*see* fig. 27). There are four lights in the long arm, the first two 50 yards apart and the next two at intervals of

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100 yards: the cross of the T is marked by two lights 100 yards distant from and at right angles to the fourth flare of the long arm on either side thereof:—

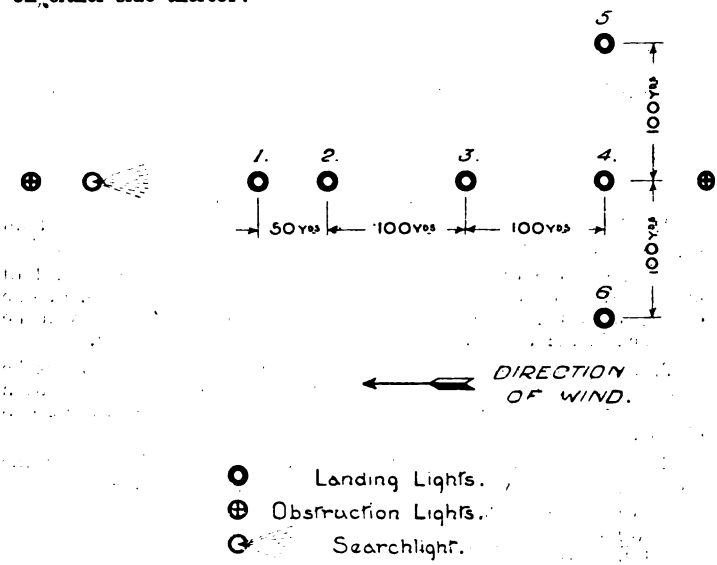

FIG. 27.—LAY-OUT OF LANDING FLARES.

The distances between the cross flares may be reduced where space does not permit of the flare path being laid out to the dimensions shown above, but in no case will be less than 75 yards.

10. If a searchlight is used it will be placed in line with the long arm of the T, with the beam directed up-wind. In cases where pilots are landing by means of wing-tip flares only, or where landing flares cannot be provided, the searchlight may be used to mark a suitable landing place and will be directed up-wind to denote the direction of the wind, or the direction in which the landing should be effected when there is no appreciable wind. The use of the searchlight may be dispensed with when aerodrome flares are in use.

11. At each end of the aerodrome a red light (known as *boundary lights*) will be placed in line with the long arm of the T to delimit the space available for landing. The officer in charge of night flying will be responsible for the siting of these lights. The boundary light at the leeward end of the flare path will be so sited that an aeroplane on a normal glide will clear all obstacles if its wheels first touch ground between the boundary light and the first flare. The windward boundary light will be sited at a distance of 300 yards from the cross flares, or on the boundary of the aerodrome, whichever is the nearer. Aircraft must not taxy past this light.

12. A *taxying post* will be placed to mark the position that aircraft are to take up when ready to proceed and awaiting permission to take off. This post will be situated as near the hangars as convenient, and will be marked by three lights three feet apart and forming an equilateral triangle, the top light being white and the two lower lights red and green respectively.

13. High W/T masts in the vicinity of an aerodrome will be marked with distinctive lights. No other obstruction lights (with the excep-

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tion of those placed to mark the position of a crashed aircraft) will be displayed on an aerodrome. Pilots will therefore treat the whole area of the station as one of danger.

14. Pilots may take off and land on either side of the long arm as convenient, so long as both cross flares (Nos. 5 and 6) are lit; in the event of one side of the flare path becoming temporarily obstructed, the cross flare on that side will be extinguished, but pilots may be permitted to take off and land on the other side of the long arm.

15. All night-flying aircraft will be fitted with wing-tip landing flares. Pilots will be instructed in their use and will be warned of the danger of using them in clouds, fog or mist.

16. Requests for the lighting of aerodromes or landing grounds will be addressed to the headquarters of the area or command direct, whence the necessary instructions will be issued direct to the aerodromes or landing grounds concerned. The following abbreviated messages will be used by units or stations when communicating their requirements and by headquarters when issuing their instructions :—

(*a*) "NIGHT FLYING" (followed by the names of the aerodromes and/or landing grounds which are required to be lighted).—The recipient of this message will take steps to ensure that flares can be lit within 15 minutes of the receipt of the message under (*c*) below. The sender of this message will allow two hours from the time of despatch of the message for the aerodrome or landing ground concerned to reach a state of readiness.

(*b*) "NIGHT FLYING OFF" (followed by the names of the aerodromes and/or landing grounds at which lighting is not required).—This message cancels part or all of message (*a*).

(*c*) "LIGHTS" (this will be understood to cover all aerodromes and landing grounds mentioned in message (*a*) unless cancelled by message (*b*)).—If possible, the times between which the lights are required should be stated. If the times are not stated the lights will be lit immediately and kept alight until receipt of message (*d*). If message (*d*) is not received the lights will be kept alight until daybreak.

(*d*) "OUT LIGHTS" (followed by the names of the aerodromes and/or landing grounds at which lights are no longer required).—This message need not be sent if the times have already been given in message (*c*). On receipt of this message landing lights will be extinguished.

Note.—It is important that headquarters should be informed as soon as possible when landing lights are no longer required.

Section C—Regulations for Aircraft.

17. Navigation lights will be kept lit on all aircraft standing on the aerodrome.

18. Each aircraft in a squadron will be allotted a distinguishing letter which will be marked conspicuously in the cockpit. The distinguishing letter will be used on all occasions when signalling to the aerodrome control officer (*see* Sections "D" and "E"). When communicating with an aerodrome other than the aircraft's own aerodrome the squadron W/T call-sign, or sector letter in the case of fighters, must be prefixed to the aircraft's distinguishing letter.

19. All signals received by aircraft, whether in the air or on the ground, will be answered. A negative (or "red") signal will be answered by the Morse letter T signalled on the upper and lower identification lights. An affirmative (or "green") signal will be answered by switching on the identification lights, which will be

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left on until the evolution for which permission has been received is completed.

20. When ready to proceed and while awaiting permission to take off, aircraft will assemble at the taxying post.

21. Aircraft must not taxy across the line of flares; aircraft will taxy from hangars or taxying post to flare path, and from flare path to hangars, by a route selected by officer in charge of night flying, keeping a look-out for obstacles.

22. When in the vicinity of an aerodrome and awaiting permission to land, service aircraft will fly on right-hand circuits.

23. Except in an emergency, aircraft, when in the vicinity of an aerodrome and awaiting permission to land, must not fly below 1,000 feet.

24. If a pilot be forced, by engine failure or other cause, to land, he will make the distress signal to the control officer by :—

(i) a series of short flashes on the identification lights, or
(ii) firing red signal cartridges, or
(iii) a red light on a signalling lamp.

After making the distress signal the pilot will switch on the identification lights, which will be left on until the aircraft has landed. The control officer will make every effort to clear the flare path and will cancel any permission to proceed or to land previously given to any other aircraft (*see* paras. 30 and 34).

25. A succession of short flashes on a searchlight directed vertically will indicate a "general recall." Aircraft will return to the nearest aerodrome which has night-flying organisation ready, where they will await permission to land in accordance with Section "E."

26. The attention of all pilots is directed to the international distress signal at sea which is "Rockets or shells of any colour fired, one at a time, at short intervals." This signal should be used by any aircraft forced landing at sea and requiring assistance. The use of pyrotechnic lights by aircraft when over or in the vicinity of the sea for any purposes other than distress signals is forbidden.

Section D—Despatch of Aircraft.

27. When a pilot is ready to take off, he will taxy to the taxying post and request permission to proceed from the aerodrome control officer by signalling his distinguishing letter on the upper and lower identification lights.

Note.—A signaller may be necessary as an intermediary between the pilot and the aerodrome control officer.

28. Permission to proceed will be indicated by the aerodrome control officer repeating the distinguishing letter of the aircraft concerned in green. Refusal of permission to proceed will be indicated by repeating the distinguishing letter in red, or, if the distinguishing letter is not known, by directing a red light at the aircraft.

29. When permission to proceed is received the pilot will taxy to the flare path by the route indicated by the officer in charge of night flying, and, on reaching No. 1 flare, will take off without unnecessary delay. Pilots may take off on either side of the long arm of the T, provided that both cross flares are lighted. (*See* para. 14.)

30. In the event of a distress signal being sighted (*see* para. 24), the aerodrome control officer will cancel the permission to proceed given to any aircraft by signalling its distinguishing letter in red or, if the distinguishing letter is not known, by directing a red light at the aircraft, when it will taxy away from the line of flares as quickly as possible.

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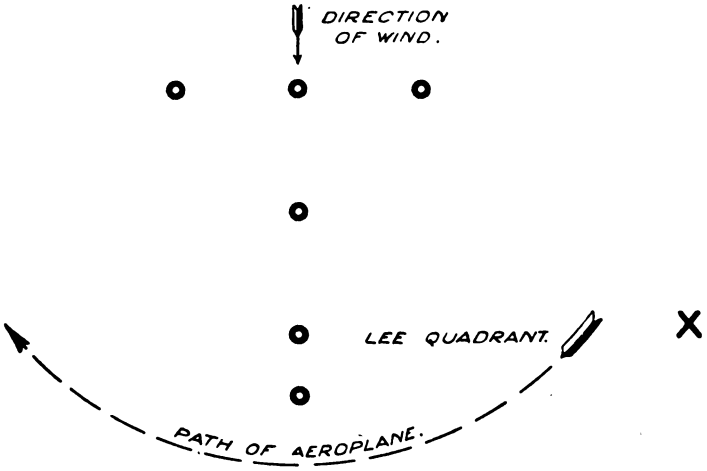
Section E—Arrival of Aircraft.

31. On arrival in the vicinity of an aerodrome at which he wishes to land, and when on a right-hand circuit entering the lee-quadrant, the pilot will signal his distinguishing letter on his upper and lower identification lights (preceded by his squadron W/T call-sign, or sector letter in the case of fighters, if the aerodrome is not his own aerodrome). If the identification lights fail the signals will be made on a signalling lamp or, if a signalling lamp is not available, by firing a green signal cartridge. Signals requesting permission to land will not normally be made at heights above 2,000 feet.

32. Permission to land will be indicated by the aerodrome control officer repeating the distinguishing letter of the aircraft concerned in green. Refusal of permission to land will be indicated by repeating the distinguishing letter of the aircraft in red, or if the distinguishing letter is not known, by directing a red light at the aircraft.

33. After receipt of refusal of permission to land, or if no reply is received to the request for permission to land, the pilot will remake the signal after completing a circuit of the aerodrome and when entering the lee-quadrant. An aircraft which has passed the entrance to the flare path before it receives permission to land will not turn back, but will complete another circuit of the aerodrome before landing.



X - Position where request for permission to land signal is made.

FIG. 28.—NIGHT LANDING—PATH OF AIRCRAFT.

34. On sighting the distress signal (*see* para. 24), a pilot who has received permission to land will consider the permission cancelled, and will wait until the aircraft in distress has landed and is clear of the flare path. He will then remake the request for permission to land as directed in paragraph 33.

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Summary of Standard Signals for Night Flying

Signal.	Colour.	Sent by
1. A succession of short flashes on a searchlight directed vertically.	White	Aerodrome control officer.
2. Distinguishing letter of aircraft signalled in Morse code on identification lamp.	White	Pilot of aircraft.
3. Distinguishing letter of aircraft repeated on a signalling lamp, in GREEN.	Green	Aerodrome control officer.
4. Distinguishing letter of aircraft repeated on a signalling lamp, in RED, or a red light directed towards the aircraft. (The distinguishing letter should be signalled whenever possible.)	Red	Aerodrome control officer.
5. Distinguishing letter of aircraft signalled in Morse code on identification lamp (preceded by Squadron W/T call sign, or sector letter in the case of fighters, if aircraft is landing on aerodrome other than its own). If failure occurs in the identification lamp, the signal may be made on a signalling lamp, if available, or by firing a green signal cartridge.	White lamp or green signal cartridge.	Pilot of aircraft.
6. Distinguishing letter of aircraft repeated on a signalling lamp, in GREEN.	Green	Aerodrome control officer.
7. Distinguishing letter of aircraft repeated on a signalling lamp, in RED, or a red light directed towards the aircraft. (The distinguishing letter should be signalled whenever possible.)	Red	Aerodrome control officer.
8. (*a*) Series of short flashes on identification lamp.	White	Pilot of aircraft.
or (*b*) Firing Red signal cartridges -	Red	
or (*c*) Red light on signalling lamp -	Red	
9. (*a*) Series of short flashes in RED on a signalling lamp directed at aircraft which has previously been given permission to land;	Red	Aerodrome control officer.
& (*b*) Firing red signal cartridges -	Red.	

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Control at Royal Air Force Aerodromes.

Sent to	Interpretation.	Remarks.
All aircraft in the air.	General recall -	Aircraft will return to nearest aerodrome and request permission to land (*see* signal 5 below).
Aerodrome control officer.	Aircraft ready to proceed.	——
Pilot of aircraft.	Permission given to proceed.	——
Pilot of aircraft.	Aircraft denoted not to proceed, or cancellation of previous order to proceed.	If in cancellation of previous order to proceed, aircraft will taxy away from flare path as quickly as possible.
Aerodrome control officer.	Requesting permission to land.	Signal to be made when aircraft is on a right-handed circuit entering the lee-quadrant of the flares.
Pilot of aircraft.	Permission is given for aircraft denoted to land.	——
Pilot of aircraft.	Permission to land is refused.	Pilot will remake signal asking for permission to land after he has made a circuit of the aerodrome.
Aerodrome control officer.	Forced to land owing to engine failure or other cause.	An aircraft which has received permission to land will, on sighting a distress signal, consider its permission to land cancelled.
Pilot of aircraft.	Cancels permission to land.	Pilot will remake signal asking for permission to land after he has made a circuit of the aerodrome.

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APPENDIX II

USE OF OXYGEN IN HIGH FLYING

1. The chief reason for the administration of oxygen to aviators is that when flying at higher altitudes (20,000 feet and higher) certain symptoms manifest themselves which are due chiefly to the rarefaction of the atmosphere causing insufficient oxygenation of the body. These symptoms are :—

(i) Breathlessness.
(ii) Muscular weakness.
(iii) Impairment of judgment and perception.
(iv) Drowsiness.

2. As regards flying, the effect of increasing altitude, apart from the question of temperature, is a deepening of the respiration in order to secure the oxygen necessary to maintain the bodily functions. At the same time the heart quickens, and an increase in the rate of the heart beats means an increase in the amount of work done by the heart. This increased work entails an increased oxygen consumption, the supply of which is diminishing; thus each factor reacts unfavourably upon the other. Furthermore, with prolonged strain a breakdown of the respiratory and circulatory mechanisms, involving also the nervous system, may occur unless appropriate measures are taken to mitigate the ill effects. All the devices to render the respiration and circulation efficient will, therefore, be called into play to meet the changing conditions.

3. Effective expiration is sometimes hampered by the positive pressure of the slip stream of the airscrew and the contrary wind induced by the speed of the aeroplane. The position of the pilot in the aeroplane is such also that but little help can be rendered by the pumping action of muscle movement, and even allowing for the relief given through the respiratory mechanism this is liable to become fatigued so that the effective return of blood to the heart is hampered.

4. As regards mitigation of such ill effects, it has been shown that oxygen greatly improves the condition of athletes. Administered *before* a short period of exertion it may improve the time of the performance, and certainly alleviate the distress of it. It greatly diminishes the distress caused by a previous exertion, and increases the staying power of the performer. Administered during the performance of work, it increases the amount done and the ease of performance. If administered *after* a period of long work, it decreases the subsequent symptoms of fatigue—the subject suffers little or no "stiffness" or other after effects.

5. Briefly stated it has been shown that the administration of oxygen :—

(i) Tends to keep an efficient slow pulse.
(ii) Tends to keep up a good arterial pressure.
(iii) Keeps off the onset of distressed breathing.
(iv) Mitigates any ill effect due to excessive deep breathing.
(v) Increases the power for nervous concentration and muscular work.

6. The sole purpose of the employment of oxygen in the air is to maintain the efficiency of pilots and observers.

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7. It is common knowledge that oxygen is necessary for life. It is only in the presence of oxygen that the processes of combustion can take place, by which the potential energy of the food which we eat is converted into other forms of energy, viz., heat and work. Oxygen is carried by the blood to all parts of the body. It is taken up by the blood as it circulates through the lungs, the amount taken up depending on the pressure exerted by the oxygen in the air. If the pressure diminishes, less oxygen will be taken up and symptoms of "oxygen want" will supervene.

8. The air consists (approximately) of 80 per cent. nitrogen and 20 per cent. oxygen. The pressure exerted by these two gases acting together is 30 inches, or 760 mm. of mercury at sea-level. This is known as the atmospheric pressure. The pressure exerted by the oxygen alone is therefore 20 per cent. of 760 = 152 mm. Hg. It is clear that the pressure of the oxygen will be lowered either by a lowering of the atmospheric pressure, or by a fall in the percentage of oxygen while the atmospheric pressure remains unaltered. For example, if instead of the normal proportions at ground-level, the air contains 90 per cent. nitrogen and only 10 per cent. oxygen, the pressure exerted by the latter is :—

$$\frac{10}{100} \times 760 = 76 \text{ mm. Hg.*}$$

9. Again at 19,000 feet, although the composition of the air is unaltered, the total (atmospheric) pressure is only half the normal. Hence the pressure exerted by the oxygen is :—

$$\frac{20}{100} \times 380 = 76 \text{ mm. Hg.}$$

10. In both examples, therefore, the pressure which drives the oxygen into the blood is only half the normal, and accordingly the body will receive only half what it is accustomed to.

11. It may here be mentioned that many pilots and observers declare that they are perfectly fit at 19,000 feet. Now, man was built for living on the ground, and it is in the highest degree improbable that Nature would have supplied him with a given amount of oxygen if half that amount would have done just as well. Further, if an aeroplane were to be flown off the ground from sea-level, and landed on a mountain aerodrome at 16,000 feet, very few individuals would be able to walk more than 50 yards. This means that the reason why a pilot feels fit in an aeroplane at high altitudes is because he is sitting comparatively still. It suggests, however, that perhaps he is not as fit as he feels.

12. All healthy individuals can fly at the heights at present attained, enduring it is true a certain amount of discomfort, without oxygen. But if the altitudes are great and the flight prolonged, loss of efficiency inevitably results, and is followed after a comparatively short period by non-effectiveness for high-flying which may prove permanent. The use of oxygen prevents this.

13. All high flying aircraft are equipped with oxygen apparatus which is so regulated that the amount of oxygen breathed from the external air plus that supplied by the apparatus are together equal to the amount available on the ground. *In other words, it keeps the pilot under normal, instead of artificial* conditions. It follows that if oxygen is carried, it should be used throughout the flight, commencing directly the aircraft has left the ground, or just before. *It should not be reserved until the individual feels he wants it, it having been shown above that the particular effects of want of oxygen which matter most are not noticed by the individual.*

---

* Hg. = Mercury.

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14. There are two methods of delivering oxygen (i) by a mask, and (ii) by a pipe. The former is the more satisfactory, because it ensures the whole amount of oxygen delivered reaching the lungs. There is no danger of the tube being blocked by frozen condensation, water or saliva, and it protects the face from frostbite. The mask can easily be removed. If removed at 20,000 feet, it would not suddenly cause faintness as is sometimes supposed; on the contrary it would benefit the pilot owing to the fact that his normal reserve of oxygen has been maintained at its proper level.

15. The advantages derived from the use of oxygen at high altitudes are :—

(i) It maintains mental alertness.
(ii) It maintains muscular efficiency.
(iii) It permits the pilot to benefit by the tactical advantages of height without experiencing its disadvantages.
(iv) It helps to keep him warm.
(v) It abolishes the disagreeable symptoms—headache, lassitude, etc.—which are sometimes experienced after long flights at high altitudes.
(vi) By its beneficial action on individual flights, it prevents the gradual onset of the physical fatigue which otherwise tends to supervene after a prolonged period of high flying.

16. Finally, it should be borne in mind that oxygen in no way acts upon the body as a 'dope.' It is the normal function of the blood to carry oxygen, and the degree of this carrying power is limited. Therefore, no matter how great the supply of oxygen available in the lungs, the blood can only carry oxygen to the tissues up to the limit of its carrying power, and there is, therefore, no danger of "increased combustion" or 'doping' of the tissues. Moreover, owing to this fact, unnecessary waste is avoided by the adjustment of the oxygen apparatus to give only the amount of oxygen necessary to bring the amount inspired up to that existing in the air at ground-level.

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